PB90-220658

Superfund Record of Decision (EPA Region 9): Firestone Tire and Rubber Company, Inc. Site Salinas, California (First Remedial Action), September 1989

(U.S.) Environmental Protection Agency, Washington, DC

13 Sep 89

U.S. Department of Commerce
National Technical Information Service
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Firestone Tire (Salinas Plant), CA
First Remedial Action - Final

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U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

The 256-acre Firestone Tire (Salinas Plant) site is in an agricultural area in Salinas, California. The facility was operated as a tire manufacturing plant from 1963 to 1980, in which a variety of chemicals and chemical formulations were used including solvents and surfactants. In 1983, as part of the requirements for the closure of a RCRA-regulated storage area at the facility, Firestone conducted an environmental investigation and determined that some chemicals had been released to the soil and ground water. Sampling indicated that a plume of VOC-contamination extends about 2 1/2 miles northwest of the former facility. Consequently, onsite and offsite ground water pumping and treatment was initiated to further reduce chemical migration. Furthermore, evaluation of potential sources of contamination resulted in cleaning and removing storage tanks and above-ground facilities, as well as excavating 5,300 cubic yards of inorganic- and organic-contaminated soil for final disposition offsite. This final remedy provides for additional cleanup of ground water under the site and as much as 2 1/2 miles from the site. Soil analytical data indicated that the residual risk from soil contamination after remedial measures had been implemented warranted no further soil remediation. The primary contaminants of concern affecting the ground water are VOCs including 1,1-DCA, 1,1-DCE, 1,1,1-TCA, TCE, PCE, benzene, toluene, and xylenes.
(Continued on next page)

17. Document Analysis a. Descriptors

Record of Decision - Firestone Tire (Salinas Plant), CA
First Remedial Action - Final
Contaminated Media: gw
Key Contaminants: VOCs (1,1-DCA, 1,1-DCE, 1,1,1-TCA, TCE, PCE, benzene, toluene, xylenes)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report) None

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22. Price

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See Instructions on Reverse

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EPA/ROD/R09-89/039
Firestone Tire (Salinas Plant), CA

16. Abstract (Continued)

The selected remedial action for the site includes pumping and treatment of ground water at the existing treatment facility using carbon adsorption and air stripping, with offsite discharging of treated ground water to surface water; ground water monitoring to ensure that the ground water plume is declining; crop testing to ensure that there is no plant uptake of the contaminants; and developing a contingency plan for water in the deep aquifer in case of contamination. The estimated present worth cost for this remedial action is $1,742,000, which includes an estimated O&M cost of $1,517,000 for 3 1/2 years.

United States
Environmental Protection
Agency

Office of
Emergency and
Remedial Response

PB90-220658

EPA/ROD/R09-89/039
September 1989

EPA

Superfund Record of Decision:

Firestone Tire (Salinas Plant), CA

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U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

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RECORD OF DECISION
DECLARATION

Firestone Tire and Rubber Company, Inc. Site
Salinas, California

Statement of Basis and Purpose

The Firestone Tire and Rubber Company Site ("Firestone Site"), located in Salinas, California, was added to the National Priorities List in 1987, and is subject to the requirements put forth in the Comprehensive Environmental Response, Compensation and Liability Act. The California Department of Health Services ("DHS") approved the remedial action for the Firestone Site in accordance with California Health and Safety Code at 25300 et. seq., CERCLA, the National Contingency Plan, and applicable or relevant and appropriate requirements for the site. This document serves as EPA's selection of remedy which fully supports the decision made by DHS. The DHS is serving as the lead agency for Superfund activities at the Firestone Salinas Site.

EPA's selection of the remedy chosen by DHS is based upon the Remedial Action Order, Remedial Investigation, Risk Assessment, Feasibility Study, the Remedial Action Plan ("RAP"), the Response Summary, and the Administrative Record for this site. The administrative record index is attached to this document, and the administrative record file is closed with the signing of this document.

Description of Remedial Action

Firestone Tire and Rubber Company has been performing an RI/FS at the site since 1986. A RCRA closure was completed in 1984 which addressed soil contamination at the site before the facility closed down. Firestone has been pumping and treating groundwater at the facility since 1984 at an on-site groundwater treatment plant. Since that time, groundwater contaminant concentrations have significantly declined.

The final remedy provides for cleanup and cleanup requirements for groundwater under the site and extending to a distance of over 2 miles from the site. The major components of the final selected remedy include:

- Pumping of groundwater from the shallow 60-80 foot hydrogeological zone for treatment;
- Pumping of groundwater from the intermediate 120-180 foot hydrogeological zone for treatment;
- Treatment of extracted water by carbon adsorption and air stripping under a permit by the Monterey Air District;
- Discharge of treated water to the Salinas River under an NPDES permit issued by the Regional Water Quality Control Board, San Louis Obispo Region;
- Regular monitoring to ensure that the size of the groundwater plume is declining and to allow for adjustments to the system;
- Crop testing to ensure there is no uptake of contaminants by plants;

1.C

- A contingency plan for currently uncontaminated water in the deep aquifer which becomes contaminated and is found not to be effectively remedied.

Declaration

EPA, under CERCLA, has selected this remedy for the Firestone Site. The remedy is protective of human health and the environment, attains Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost- and time-effective. This remedy satisfies Federal statutory preferences for remedies that reduce toxicity, mobility, or volume of contaminants as a principal element. It also utilizes permanent solutions to the maximum extent practicable. The remedy also addresses and provides for the 5-year review provision at CERCLA Section 121(c). If this selected remedial action does not meet the goals and cleanup objectives identified in the remedy, or is not sufficiently protective of human health and the environment, then EPA may, under the authorities of CERCLA, require additional response action from Firestone.

9.13.89
Date

John Wise
John Wise
Deputy Regional Administrator

Concurrences for Firestone Salinas Superfund Site ROD

I concur with the remedy selected by the State of California and recommend that the Deputy Regional Administrator sign the Concurrence Record of Decision.

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INTERNATIONAL
TECHNOLOGY
CORPORATION

Project No. 190067
August 1989

Final

Feasibility Study/ Remedial Action Plan

Former Firestone Facility
Salinas, California

The Firestone Tire & Rubber Company
Akron, Ohio

Volume I - Text

RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

i.f

FEASIBILITY STUDY/REMEDIAL ACTION PLAN
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

Project No. 190067

PREPARED FOR

The Firestone Tire & Rubber Company
1200 Firestone Parkway
Akron, Ohio 44301

PREPARED BY

IT Corporation

August 1989

Final Revision

i.g

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EXECUTIVE SUMMARY

Firestone Tire & Rubber Company operated a tire-manufacturing plant from 1963 to 1980 at 340 El Camino Real South, about 6 miles southeast of downtown Salinas, California. During operation, the plant used a variety of chemicals and chemical formulations to make tires. Firestone began environmental investigations in March 1983 as part of the requirements for closing the Resource Conservation and Recovery Act (RCRA) storage area at the facility. Firestone subsequently determined that some chemicals had been released to the soil and ground water. The nature and extent of these chemicals in the ground water were thoroughly assessed and were documented in the Remedial Investigation report issued to the Department of Health Services in December 1988.

As reported in the Remedial Investigation, two groups of chemicals were found in the ground water both on and off site: chlorinated aliphatic hydrocarbons and volatile aromatic hydrocarbons. The chlorinated compounds included the following:

- 1,1-Dichloroethane (1,1-DCA)
- 1,2-Dichloroethane (1,2-DCA)
- 1,1-Dichloroethene (1,1-DCE)
- 1,1,1-Trichloroethane (1,1,1-TCA)
- Trichloroethene (TCE)
- Tetrachloroethene (PCE).

The aromatics included the following compounds:

- Benzene
- Toluene
- Ethylbenzene
- Xylene (3 isomers).

In general, the chemicals most commonly found in the ground water in the vicinity of the facility are 1,1-DCA; 1,1-DCE; and 1,1,1-TCA. Concentrations are found in the micrograms per liter (parts per billion) range in on- and off-site ground water. The seven other chemicals are found either in lower concentrations or not at all in most wells.

The ground-water aquifer system at the facility is comprised of three interconnected zones that are designated shallow, intermediate, and deep. The shallow aquifer extends from about 30 feet below the surface to a depth of about 90 feet. The intermediate zone is generally between depths of about 100 and 140 feet below the surface. The deep aquifer system locally has up to four zones at approximately 200-, 300-, 400-, and 500-foot depths.

Analyses of samples from monitoring, agricultural, domestic, industrial, and municipal water wells indicate that the chemical plume extends about 2-1/2 miles northwest of the former Firestone facility. The plume of chemicals in the ground water can be described as follows, starting at the facility:

- A narrow ellipse 3,000 feet long and 1,000 feet wide, in the shallow aquifer, flowing almost due west
- A second, narrow ellipse 4,000 feet long and 1,000 feet wide, in the intermediate zone, flowing northwest
- A third ellipse 7,000 feet long and 1,500 feet wide, in the deep aquifer flowing northwest.

The concentrations of chemicals in the ground water have been decreasing since monitoring began in 1983. The range of concentrations in micrograms per liter, μg/ℓ, from April 1988 to March 1989 was as follows:

Zone	Depth (feet)	1,1-DCE	1,1-DCA	1,1,1-TCA
first ellipse	<90	2 to 90	2 to 36	1 to 38
second ellipse	100 to 140	ND to 52	ND to 8	ND to 27
third ellipse	>200	ND to 23	ND to 11	ND to 16

Interim remedial action to clean the ground water began as soon as Firestone was aware of the problem. Initially, extraction wells were drilled into the shallow aquifer on site, in a line just northwest of the plant buildings. A ground-water treatment system was installed after Firestone received approval from State and county regulatory agencies. Subsequently, extraction wells have been drilled off-site to the northwest, again penetrating into the shallow aquifer.

IT prepared a preliminary risk assessment relative to ground-water use for this project in October 1988. The risk values presented in that report were updated in the Remedial Investigation (RI) report issued in December 1988. The risks have continued to decrease as the concentrations of chemicals in the ground water are reduced by the treatment system.

Four ground-water ingestion scenarios were analyzed in the December 1988 RI report to evaluate potential risk to humans:

- Current use of affected ground water (an existing well)
- Hypothetical well in shallow aquifer (90 feet)
- Hypothetical well in intermediate zone (120 feet)
- Hypothetical well in deep aquifer (220 feet).

In each scenario, risks from carcinogens and noncarcinogens were calculated separately. For carcinogens, the nonsignificant risk level was set at 1×10^{-6} (one in one million) additional risk due to lifetime consumption of contaminated ground water from the well. For noncarcinogens, a health index was calculated, comparing the allowable drinking water standard with the actual concentration in the affected ground water. The comparison is the ratio of actual concentration to the allowable concentration. An index value of less than one means that the exposure level is less than the allowable human intake level. The following table summarizes the health risk assessment results presented in the December 1988 RI report:

WELL SCENARIO	CARCINOGEN RISK	HEALTH INDEX
Existing Shallow Aquifer	less than 1×10^{-6}	0.02
Hypothetical Shallow Aquifer	1.6×10^{-6}	1.4
Hypothetical Intermediate Zone	less than 1×10^{-6}	0.87
Hypothetical Deep Aquifer	less than 1×10^{-6}	0.2

Based on this risk assessment, the only scenario that shows risks above the acceptable levels is use of a hypothetical domestic well placed in the maximum contamination point of the shallow aquifer. This is the portion of the plume with ground water currently being extracted and treated to reduce the contaminant levels. The effect of continuing treatment in reducing the concentrations was not included in the risk assessment results given above.

In addition to presenting carcinogenic risks and health indices, the risk assessment also establishes concentrations that will protect public health. Preliminary health-protective tap-water concentrations were calculated for both carcinogens and noncarcinogens. The results are as follows:

• Carcinogens	
- 1,2-DCA	0.5 µg/ℓ
- TCE	3.2 µg/ℓ
- PCE	0.7 µg/ℓ
- Benzene	0.8 µg/ℓ

• Noncarcinogens	• Unfactored	• Factored
- 1,1-DCE	290 µg/ℓ	5.8 µg/ℓ
- 1,1-DCA	230 µg/ℓ	46 µg/ℓ
- 1,1,1-TCA	340 µg/ℓ	68 µg/ℓ
- Toluene	120 µg/ℓ	24 µg/ℓ
- Ethylbenzene	58 µg/ℓ	11.6 µg/ℓ
- Xylene	340 µg/ℓ	68 µg/ℓ

Based on the results of this site-specific risk assessment, these concentrations would be acceptable for a lifetime of daily use of the ground water. The unfactored values for noncarcinogens are total exposure values. The factored values incorporate a standard 20 percent factor for the contribution from drinking water plus, in the case of 1,1-DCE, an additional uncertainty factor of 10. These values were rounded off for presentation in the Risk Assessment report. These health-protective values are based on the cumulative health effects of noncarcinogens with common target organs. The numerical values are based on the respective contributions of each compound to the health index at the time the risk assessment was prepared. However, the contribution to the health index for the chlorinated compounds is dominated by 1,1-DCE (93 percent) and for the aromatics by xylene (97 percent), so the relative contributions are not expected to change significantly.

This FS/RAP establishes cleanup criteria as follows:

- Cleanup levels must result in a cumulative health index of less than 1 considering the noncarcinogens with common target organs.
- Cleanup levels must result in a carcinogenic risk of less than 1 x 10^{-6} for each carcinogen.
- Cleanup levels must comply with each compound-specific applicable or relevant and appropriate requirement.

For purposes of this FS/RAP and the trade-off comparisons between alternatives, the health-protective levels given above were used with the compound-specific applicable or relevant and appropriate requirements to estimate the cleanup levels. However, the actual concentrations of each compound will be used with the above criteria to assess when remediation is complete.

The residual risks associated with the chemicals in the soil above the ground water near the plant have also been assessed.

Eleven areas were identified in 1983 as potential sources of contamination. Three of these were inside the plant, and eight were outdoors. The indoor areas were judged not to be potential sources of contamination following cleaning and inspection for areas of leakage. In the eight outdoor areas, the storage tanks and above-ground facilities were cleaned and removed. The exposed soils were tested for inorganic and organic chemicals. As a result of this testing and visual inspections, contaminated soils were excavated and disposed of at an off-site, hazardous-waste landfill. These removals ranged from removal of visibly stained soil to an excavation of 5,300 cubic yards of soil. The soil cleanup levels established in 1983 and 1984 for this work were based on STLC and TTLC values. This FS/RAP assesses the residual risk of the chemicals remaining in the soil after cleanup.

The chemicals remaining in the soil after the 1983-84 cleanup were predominantly oil and grease, phthalates, and metals (predominantly zinc, as zinc oxide, lead, and nickel). Testing showed that the oil and grease were not water extractable. A risk assessment considering ingestion and dermal contact with the oil and grease shows an acceptable risk. The metals are typically at below background levels. The phthalates are at very low levels. Considering these factors with the low potential for migration and the fact that the areas are covered with heavy-duty truck pavement in the middle of an industrial park, the residual risk from soil contamination is judged acceptable.

A variety of physical, chemical, biological, and thermal treatments were considered to remediate the low concentrations of chlorinated hydrocarbons in the ground water at the site. The technology screening step in the FS process resulted in identifying carbon adsorption and air stripping as viable remediation technologies. These technologies were evaluated for both centralized and dispersed treatment. The screening indicated that continuation of the centralized combination of the carbon adsorption and air stripping is the preferable technology for remediation. These are the two technologies that have been used for the interim remedial measures at the site to date.

The remediation alternatives developed for consideration were based on the relevant site characteristics. These included the presence of the chemicals in both the shallow and intermediate aquifers at concentrations above health-protective cleanup levels. In addition there is a small area in the deep aquifer where this occurs. Computer simulation indicated that the shallow aquifer remediation should continue. In addition, remediation should be initiated in the intermediate aquifer.

Six alternative pumping scenarios were considered for remediating the intermediate aquifer. These consisted of various numbers and locations of extraction wells and pumping rates. The optimum alterative was a series of five extraction wells aligned along the axis of the intermediate aquifer plume pumping from 100 to 150 gpm. In addition to these pumping scenarios, three disposal alternatives were considered. These included river discharge, surface discharge, and injection into the shallow aquifer. Continuation of the current river discharge was indicated as the preferable alternative.

Five alternatives to remediate both the shallow and intermediate aquifers were analyzed in detail. These consisted of a no-action alternative, and four combinations of pumping from different sets of wells in the shallow and the intermediate aquifers. Computer simulations were made of each of the five final remedial alternatives to assess the relative effectiveness and time required to achieve cleanup for each alternative.

The no-action alternative consists of stopping the current pumping and treating. This alternative is presented as a baseline alternative for comparison with the other alternatives. For this alternative the shallow aquifer plume migrates toward the northwest, following the regional groundwater gradient. Eventually this plume merges with the intermediate aquifer and continues flowing with the regional gradient. Some dilution and dispersion occurs naturally with this alternative. The computer simulation indicates that, for this no-action alternative, both the shallow and intermediate aquifers will reach the cleanup concentrations in about 5 to 10 years. This was used as a relative cleanup period of 1.0 for comparison with the other alternatives.

The second remedial alternative consists of continuing to pump and treat the ground water from the shallow aquifer. No pumping and treating is done in the intermediate aquifer. Compared with the no-action alternative, the shallow aquifer reaches cleanup levels in half the time; however, the intermediate aquifer takes the same time since no remediation is done directly in the intermediate aquifer. The reduction in mass loading from the shallow aquifer to the intermediate aquifer has little effect on the time to reach the cleanup levels in the intermediate aquifer.

The third remedial alternative consists of continuing to pump and treat the ground water from the shallow aquifer. In addition, five new extraction wells are installed in the intermediate aquifer. These new wells are pumped at rates from 100 to 150 gpm concurrently with the ongoing pumping from the wells in the shallow aquifer. Thus, the combined pumping rate exceeds the current treatment plant capacity and the current NPDES permitted flow rate. Therefore, a new 500 gpm air stripper is added to the treatment plant for this alternative. This also requires a new air discharge permit. This alternative involves potential delays in obtaining the new permits as well as delays in obtaining access to the new well locations and for a new segment of pipeline. However, assuming these new wells can be installed and operating by the fall of 1989, the shallow aquifer will reach the cleanup levels in half the time of the no-action alternative. The intermediate aquifer is projected to reach the cleanup levels in 30% of the time required for the no-action alternative.

The fourth remedial alternative consists of continuing to pump and treat the ground water from the shallow aquifer. In addition, five new extraction wells are installed in the intermediate aquifer, as for the third alternative. However, for this alternative the combined flow rates for both the shallow and intermediate aquifer wells will be maintained below 650 gpm, the current treatment plant capacity. Thus, no new permits, with the associated potential delays, would be required. There are still the delays required to obtain the access agreements for the new well locations and the new pipeline segment. However, assuming these new wells are installed and operating by the fall of 1989, a computer simulation indicates the pumping rates can be adjusted such that both the shallow and intermediate aquifers can reach the cleanup levels in 60% of the time required for the no-action alternative.

The fifth remedial alternative consists of continuing to pump and treat the ground water from the shallow aquifer. In addition, two new extraction wells are installed in the intermediate aquifer. These new wells will be pumped at 150 gpm, and the combined flow rate from both the shallow and intermediate aquifers will be less than 650 gpm. Thus, the treatment plant does not need to be expanded, and no new permits are needed. Access agreements for the new well locations and the new pipeline segment are required. Assuming the new wells and pipeline are installed and operating by the fall of 1989, computer simulation indicates that pumping rates can be adjusted such that both the shallow and intermediate aquifers can reach the cleanup levels in 95% of the time required for the no-action alternative.

The recommended remedial alternative is the fourth alternative described above. This alternative achieves the cleanup levels in only 60% of the time required for either of the first two alternatives and 63% of the time for the fifth alternative. The fourth alternative is projected to take slightly longer than the third alternative (60% compared to 50% of the no-action alternative time), assuming there are no delays in permitting. However, the fourth alternative avoids the potential delays in permitting at a small incremental increase in time to achieve the cleanup levels. Thus, the fourth alternative was selected for implementation. Each of the alternatives is comparable to the others in terms of short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; implementibility; administrative feasibility; and availability of services and materials. Thus, the relative time to achieve the clean up levels is the primary discriminator used to distinguish among the alternatives.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

The overall purpose of this Feasibility Study/Remedial Action Plan is to provide the information necessary to develop a feasible and practical conceptual plan for completing the remediation of ground water at the former Firestone facility. Interim ground-water remediation had been ongoing since February 1986, as required by the California Department of Health Services' (DHS) Remedial Action Order HSA 85/86-002 (Appendix A). This Feasibility Study/Remedial Action Plan is to ensure that environmental, technical, and cost-effective objectives are met.

The environmental objective is to perform the remediation in a manner that will preserve and maintain the beneficial uses of regional ground water (i.e., domestic and agricultural uses). This objective will be met by addressing both the quality and availability of ground water. Appropriate quality standards are applied to protect ground water. Remediation strategies are considered with respect to minimizing the net use of ground water.

The technical objective is to develop a remediation plan that (1) meets the environmental, performance, and safety requirements throughout the projected remediation; (2) includes technologies with demonstrated reliability; and (3) is practical for the site-specific conditions as documented in the Remedial Investigation (RI) report prepared in December 1988 (IT, 1988a).

The cost-effective objective is to optimize the cost associated with completion of the remediation, considering both initial capital costs and operating costs for the duration of remediation.

1.2 REGULATORY BASIS

The Remedial Investigation and Feasibility Study/Remedial Action Plan have been submitted in two reports. The initial report was the Remedial Investigation (RI) submitted in December 1988. The RI defined the lateral and

- Monterey Bay Unified Air Pollution Control District Permit to Operate No. 3168A and other permits to operate associated with well development.

1.3 ORGANIZATION OF REPORT

It is not possible to conform exactly to the report format and guidance specified by each of the multiple agencies involved with this project. This report is intended to satisfy the policies and guidance with respect to feasibility studies and ground-water remediation of the involved agencies, primarily the DHS, EPA, and RWQCB.

This FS/RAP is organized as follows:

- Executive Summary
  - Summarizes the key elements of this Feasibility Study/Remedial Action Plan
- Section 1 - Introduction (this section)
  - Summarizes the background for this study and the purpose of the FS/RAP report
- Section 2 - Identifying and Screening of Technologies
  - Identifies the types of technologies and process options that were screened for this study in terms of satisfying the remedial action objectives and general response actions
- Section 3 - Developing Remediation Alternatives
  - Describes the rationale for selecting the alternatives that were chosen for detailed analyses with respect to evaluation for effectiveness, implementibility, and cost
- Section 4 - Detailed Analysis of Remediation Alternatives
  - Assesses the selected alternatives in terms of short- and long-term effectiveness; permanence; reduction of mobility, toxicity, and volume; implementibility; cost; compliance with applicable or relevant and appropriate requirements (ARARs); overall protection; state acceptance; and community acceptance

vertical extent of chemicals in the subsurface, both on site and off site, and characterized the health and environmental risks associated with them. The RI provided the basis for the subsequent Feasibility Study/Remedial Action Plan (FS/RAP) presented by this report. The FS/RAP evaluates various remediation technologies and screens a variety of alternatives. It also presents a preliminary conceptual design of the selected remedial action together with a schedule for implementation.

The FS/RAP was prepared to meet the specific requirements of the California Department of Health Services' Remedial Action Order, as well as the applicable requirements, orders, and guidance of the U.S. Environmental Protection Agency (EPA), Department of Health Services (DHS), Regional Water Quality Control Board (RWQCB), Monterey Bay Unified Air Pollution Control District (MBUAPCD), and Monterey County Health Department. Specific references include the following:

- DHS Remedial Action Order HSA 85/86-002
- California Health and Safety Code Sections 25356.1 and 25358.7
- The Comprehensive Environmental Response, Compensation and Liability Act of 1980, (CERCLA) 42 USC Section 9601 et seq as amended by the Superfund Amendments and Reauthorization Act of 1986
- The National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300, November 20, 1985
- RWQCB Monitoring and Reporting Program No. 85-24
- RWQCB National Pollutant Discharge Elimination System Permit No. CA 0048950
- EPA Guidance Document for Conducting Remedial Investigations and Feasibility Studies (EPA 1988)
- DHS Site Mitigation Decision Tree
- Monterey County Health Department, Division of Environmental Health, Permit for Construction, Repair, or Destruction of Water Wells

- Section 5 - Recommended Remedial Action
  - Summarizes the key findings and conclusions from the FS/RAP and presents a conceptual plan of the recommended remedial action
- Section 6 - Responsiveness Summary
  - Summarizes the comments received following the public review period after the draft of this report is issued. This section is not included in the draft FS/RAP; it will be incorporated into the final FS/RAP.

1.4 BACKGROUND INFORMATION

1.4.1. Site Description

The former Firestone facility is located at 340 El Camino Real South in Salinas, California, and covers 256 acres in the Salinas Valley, the largest intermountain valley in the Central Range. The valley trends northwest for about 90 miles from Bradley to Monterey Bay and is from 5 to 10 miles wide. The Gabilan and Diablo Mountains border the valley to the east, and the Santa Lucia Mountains border the valley to the west. Alluvial fans and terraces extend from the bordering mountains to the valley floor, where they are dissected by the Salinas River, which meanders in a relatively narrow floodplain through the valley. Elevations of the valley floor are generally less than 400 feet above mean sea level (msl). The area near the former Firestone facility ranges from about 60 to 70 feet in elevation.

The agricultural lands adjacent to the former Firestone facility are plowed and leveled on a regular basis. This flat plain is generally broken into two areas. The area to the south-southwest of the facility is a floodplain at an elevation of 45 feet, about 25 feet lower than the former plant. This area is bounded on the north by an erosional bank. At the top of this bank is a dirt farm road, locally referred to as "Scarp Road." The second area where the higher plain is broken is along Alisal Slough. The slough is a narrow channel that runs northwesterly from about 3/4 mile west of the plant to Harris Road, where it has been filled.

1.4.2. Site History

Between 1963 and 1980, Firestone Tire & Rubber Company operated a tire-manufacturing facility located at 340 El Camino Real South, approximately 6 miles southeast of downtown Salinas, California (Figures 1-1 and 1-2). Firestone's tire-manufacturing operation used a variety of chemicals and chemical formulations. The following major categories of chemicals were used:

- Carbon black
- Styrene-butadiene rubber
- Processing oils
- Zinc oxide
- Clay
- Surfactants
- Solvents
- Antioxidants
- Steel wire
- Natural rubber
- Petroleum distillate fuels.

In March 1983, Firestone began investigations at its Salinas facility to comply with closure requirements of the facility's Interim Status Document, under the Resource Conservation and Recovery Act, and of the California Department of Health Services and the Central Coast Regional Water Quality Control Board. Based on findings from the closure investigations, Firestone began on-site investigations in July 1983 to characterize the nature and extent of chemicals in both soil and ground water (Appendix B).

The findings of the early remedial investigations prompted the undertaking of interim remedial measures for both soil and ground-water cleanup. These interim remedial measures have included source control and migration control. Source control measures consisted of removing underground and aboveground tanks and excavating and disposing of contaminated soil in an off-site Class I landfill. At present, both on-site and off-site ground water is being research has demonstrated that these landfills indeed did not receive waste VC, as such. Instead, the VC is produced by bacterial degradation of chlorinated ethenes, by a step-wise process. The earlier reports provide details, but the major features are as follows:

- Stepwise degradation of PCE to TCE, TCE to 1,2-DCE (dichloroethene), and 1,2-DCE to VC
- The process requires a mildly acidic environment, such as is found in the leachate of sanitary landfills.
- No production of 1,1-DCE (The compound found in highest concentration at the Firestone site) occurs under such conditions.

Thus, vinyl chloride can result from biodegradation of PCE or TCE in the environment. However, 1,1-DCE does not result from such a process.

The reports also discuss the degradation of 1,1,1-TCA, a chlorinated ethane, in the environment. The major features are as follows:

- TCA degrades by chemical action to acetic acid and hydrochloric acid, and also produces some 1,1-DCE in the process. The 1,1-DCE yield is about 20 percent of the total TCA degraded.
- Biodegradation processes producing 1,1-DCE from 1,1,1-TCA have also been reported. The by-product of these is hydrochloric acid. In addition, 1,2-DCA (dichloroethane) is reportedly produced in TCA biodegradation. It is also known to be a contaminant of commercial grade TCA. Some 1,2-DCA is found in ground water at the site.
- These processes operate in an alkaline environment. Hence, the vinyl chloride degradation process described for chloroethenes will not operate (since it requires an acidic environment).
- Any acetic acid and hydrochloric acid produced will be neutralized by the generally alkaline medium of the site ground water. The quantities of these acids produced are exceptionally small (in the tens to hundreds of ppb range), and so the residual anions would not be detectable against background. Further, other bacteria probably will decompose acetate to CO_2 and H_2O.

extracted and treated to control further chemical migration and to reduce concentrations. The remedial activities performed up to December 1988 were described in detail in the Remedial Investigation Report submitted in December 1988 (IT, 1988a). The operating permits for these remedial activities are included in Appendix A.

The locations of wells in the shallow aquifer and in the intermediate zone are shown on Figures 1-3 and 1-4, respectively. Figure 1-5 shows the location of monitoring wells in the deep aquifer. The locations of agricultural, domestic, industrial, and municipal wells in the deep aquifer are shown on Figure 1-6. Soil sample locations and chemical concentrations are shown in Figures 1-7 through 1-14.

1.4.3. Environmental Fate of Chemicals at the Site

The Risk Assessment (IT, 1988b) and the Remedial Investigation (IT, 1988a) reports have both discussed the environmental fate of the chemicals at the site. The key question addressed in those reports is "why has vinyl chloride not been detected in the soils or ground water at the Firestone site in Salinas?" This section summarizes and expands on the explanations given in the earlier reports.

There are two classes of chlorinated solvents that were commonly used in industry during the period the plant operated (1960s to 1980s). These are the chlorinated ethenes, particularly perchlorethylene (tetrachloroethene, or PCE) and trichloroethylene (trichloroethene, or TCE); and the chlorinated ethanes, of which 1,1,1 trichloroethane (methyl chloroform, or TCA) is the only significant representative. The former Firestone tire facility at Salinas used TCA as the chlorinated solvent of choice.

As described in the earlier reports, sanitary landfills that apparently received no vinyl chloride (chloroethene, or VC) have shown significant VC concentrations in landfill gas and in liquid leachate. In some cases, VC is not detected until several years after the landfill had been closed. Much

In summary, compounds such as PCE and TCE can be degraded in the environment to vinyl chloride. The process requires an acidic environment and operates via anaerobic bacteria. These conditions, while found in municipal solid waste and sanitary waste landfills, do not exist at the former Firestone site in Salinas. Further, the solvent that was used, 1,1,1-trichloroethane, degrades to 1,1-dichloroethene by processes that operate in an aerobic, alkaline environment. These are the environmental conditions in the soil and ground water at the site. Therefore, vinyl chloride is not expected to be found in ground water at the former Firestone facility in Salinas.

1.4.4. Residual Risk from Soil Contaminants

1.4.4.1. Introduction

In 1983-84, Woodward-Clyde Consultants (WCC) carried out an intensive soil investigation and removal action in 9 areas of the Firestone-Salinas facility. Interim cleanup criteria were developed by DHS and/or by WCC. The soil cleanup levels were based on the soluble threshold limit concentrations (STLC) and total threshold limit concentrations (TTLC), which are values proposed by the State to determine if wastes containing bioaccumulative or persistent (B/P) toxic substances are hazardous.

The parameters used to establish the 1983 cleanup levels at the Firestone facility were determined after considering that over 50 individual elements and compounds were found in the soil, but only 11 were found in measurable concentrations in near-surface ground water. The concentrations in ground water were at levels 100 times less than the concentrations in the soil. This indicates that the rate and extent of leaching into the ground water has been very low for most of the soil contaminants.

WCC proposed at that time to establish the following soil cleanup levels:

- Organics: Soil concentration twice STLC

- Metals: Soil concentration equal to 50 percent of the TTLC.

The proposed soil cleanup level for metals was based on a DHS request that lead (Pb) in soil at another site being investigated by WCC be reduced through soil removal to 500 mg/Kg (50 percent of TTLC).

Initial soil and ground-water analyses were conducted for priority pollutants, metals, oil and grease, total organic carbons, total organic halogens, phthalates, and polynuclear aromatic hydrocarbons. The primary chemicals identified in the soils were (Woodward-Clyde Consultants, 1984a):

- 1,1-dichloroethene (1,1-DCE)
- 1,1-dichloroethane (1,1-DCA)
- 1,2-dichloroethane (1,2-DCA)
- 1,1,1-trichloroethane (1,1,1-TCA)
- trichloroethene (TCE)
- tetrachloroethene (PCE).
- benzene
- ethylbenzene
- toluene
- xylene
- oil and grease

Table 3-1 of the Remedial Investigation report (IT, 1988a) lists STLCs and TTLCs for all the additional chemicals found in the soil.

Based on the analytical results from the initial studies, the following chemicals were identified for future testing and have been the basis for risk assessment and the ongoing ground-water monitoring program (IT, 1988a):

1,1-DCE
1,1-DCA
1,2-DCA
TCE
PCE
1,1,1-TCA
benzene
toluene
xylene
ethylbenzene

1.4.4.2. Description of Soil Removal Activities and Analytical Data

The following 11 areas at the Firestone site were investigated in 1983 and 1984, during the initial phase of the project:

OUTDOOR AREAS

Fuel Storage Area, Area 1

Courtyard, Area 2

Raw Materials Storage and
Railcar Unloading, Area 3

Sludge-Drying Beds, Area 4

Holding Ponds, Area 5

Seepage Beds, Area 6

Waste Oil Storage and
Transfer Yard, Area 7

Evaporation Ponds, Area 8

INDOOR AREAS

Banbury Pits

Curing Room

Utility Trenches and
Outdoor Corridor

Each area was evaluated against the interim cleanup levels for each chemical and/or material. Where necessary, mitigation activities were undertaken to meet the interim soil clean-up levels.

Chemicals detected in the indoor areas were found in sludges and residues remaining after the plant shutdown. After the residuals were removed, these indoor areas were cleaned. The floors were inspected for signs of possible leakage, such as cracked, broken, or deteriorated concrete. No cracks or other signs of leakage were found and, thus, the areas were judged not to be potential sources of ground-water contamination.

The following is a summary, by area, of the type of contamination found at each of the outdoor areas, and of the type of remedial activities undertaken. Details of the analytical results before and after mitigation activities are presented in Woodward-Clyde's 1984 report. Also, for areas 3, 4 and 7, native soil excavation work was required. Analytical results are given for soil samples taken after completion of this remedial work.

Fuel Oil Storage - Area 1

This area contained eight underground fuel oil storage tanks. No detectable levels of fuel components or PCB contaminants were found. Oil samples from the tanks were found to contain 3 to 4 ppm of Aroclor 1260, a polychlorinated biphenyl (PCB) compound. After removal of the tanks, no PCB soil or groundwater contamination above the detection limits of 0.5 μg/ℓ for soil, and 0.1 μg/ℓ for water, was found. No remediation was done in this area, and after tank removal, this area was considered to be properly closed.

Courtyard - Area 2

During the plant operation the courtyard was a multipurpose area used for maintenance and storage with a cooling pond and a hazardous waste storage area.

The surface soils in the hazardous waste storage part of the courtyard contained low levels of several organic compounds (phthalate esters and polynuclear aromatics). Metals in the 100 to 200 ppm range were found in the east-west ditch and the cooling tower ditch. Soil from the ditches and an area outside of the door to the main building was removed to a depth of 6 to 18 inches and disposed of at a Class I hazardous waste disposal facility. After removal of this soil, remaining levels of organics and inorganics were found to be at background levels and below the cleanup levels prescribed in the DHS Remedial Action Order, and in the February 29, 1984 letter from DHS to Firestone.

The area does not constitute a threat to public health or ground water and no further remedial action was required. This area was accepted as properly closed.

Raw Materials Storage - Area 3

Raw materials used at the plant were transported to Area 3 by train and truck and stored in 11 underground steel storage tanks, with capacities ranging from

5,000 to 14,000 gallons. Materials that were stored in the tanks included gasoline, kerosene, acetone, hexane, wax, pine tar, naphtha, aromatic oil, and various antioxidants. The area formerly contained a silo for storing carbon black. Numerous soil and ground-water samples were collected in this area and analyzed for priority pollutants, metals, oil and grease (O&G), total organic carbon (TOC), and total organic halogens (TOX). Various chemical substances were found in greater numbers and at higher concentrations in the soil and ground water in this area than in any other area sampled during the initial investigation (Woodward-Clyde Consultants, 1984a).

An extensive cleanup of this area was carried out, including removal of all underground storage tanks, removal of soil in two phases (Phases A and B), and treatment of ground water. Phase A involved removal of all plant equipment, piping and tanks, and removal of the contaminated soil to a depth of 3 to 6 feet. Samples taken from the upper 18 inches of soil at the bottom of the excavation showed no VOCs, with the exception of 3.4 ppm of ethyl benzene in one sample. Oil and grease was still present (2,800 ppm) and chromium and zinc were detected at levels of 53 and 73 ppm.

In phase B, the area of highest contamination was excavated to a depth of 40 feet, and 5,300 cubic yards of soil were removed. After backfilling with clean soil an 8-inch asphalt cap was put in place. Subsequently, concrete has been placed over some of this area as well. During the Phase B excavation work, a soil sampling and testing program was carried out on the excavated soils. Inorganics were below background levels. Individual organic species were detected only in parts-per-billion concentrations. Oil and grease, found at levels of about 5,000 ppm, did not contain water extractable organic constituents.

Sludge-Drying Beds - Area 4

This area contained three ponds that served as drying beds for sludge from the industrial wastewater treatment plant. No volatile organic compounds were detected in the six soil samples taken in these beds, one each at the surface and at a depth of 4.5 feet in each pond. Phthalates were found at concentrations up to 4.6 ppm. Metal concentrations were generally at background levels.

Oil and grease concentrations as high as 63,000 ppm were detected in all the deeper (to 36 feet) soil samples. Leachability tests with water showed no detectable oil and grease in the water. The only remedial work performed in this area was removing 12-18 inches of contaminated top soil and replacing it with clean backfill.

Holding Ponds - Area 5

The two ponds in Area 5 were used to hold storm-water runoff that exceeded the capacity of the industrial wastewater treatment plant. No volatile compounds were found in the six soil samples taken at depths up to 14 feet, or the two ground-water samples, taken at depths of 25 feet to 35 feet. No organics or metals were found in the ground water; no soil remediation was required, based on observed soil concentrations. This area was considered properly closed.

Seepage Beds - Area 6

Area 6 contained two seepage ponds that received treated water from two sources - the sewage treatment plant and the industrial wastewater treatment plant. The results of the analyses showed the presence of phthalates and hexane in soil at the 1 ppm level and xylene at 0.1 ppm. The values of the metals, with the exception of zinc, lead, and nickel were below STLC and TTLC values. The observed values for lead, zinc, and nickel were well below the recommended interim cleanup levels developed by Woodward-Clyde. No remedial action for these areas was recommended based on the lack of potential impacts on public health or the environment.

Waste-Oil Storage and Transformer Yard - Area 7

Area 7 contained three tanks used for the storage of various processing materials. An above ground tank in the southern part of the yard was used to store caustic soda/rubber latex. A buried tank and the above ground tank in the northern part of the yard were used for the storage of waste oils.

An approximately 10-foot-diameter discolored area in the southeastern portion of the yard was also investigated. Two soil samples were collected from the excavated area after the tanks were removed. No volatiles were detected, but low levels of phthalates were found. Metal concentrations were below background, and no further remedial work was performed in this area.

Since no contaminants were detected at the site, after removing the tanks and any visually stained surficial soils, no remedial program was necessary for the transformer yard. This area was considered to be clean.

Evaporation Ponds - Area 8

Area 8 contained three ponds that were used for storing excess storm water runoff before the industrial wastewater treatment plant was built. No detectable volatile compounds were found in the three surface soil samples analyzed; low phthalate concentrations were detected. Metal concentrations were below background levels and lead and nickel were far below the interim cleanup levels.

This area did not appear to represent a threat to public health or the environment. As a result, it was recommended that this area not receive further investigation and be considered as properly closed.

1.4.4.3. Residual Soil Levels and Their Hazards

The investigations of the various source areas, Areas 1 through 8, conducted in 1983 and 1984 showed that inorganic chemical concentrations in soils in Areas 1, 2, 5, 6, 8 were at or below background levels; thus, these areas did not require remedial measures. "Background" means the average range of inorganics found in the earth's crust (EPA-OSWERSW-874, April 1983). Remedial measures were required and subsequently implemented at Areas 3, 4 and 7, where the soils left in place contained low levels of some volatile or semi-volatile organic compounds. In many cases, significant levels of "oil and grease" were detected (concentrations in the 1,000 to 50,000 ppm range). In each case, the oil and grease was extracted with deionized water, and the extracts tested for oil and grease. In all such extracts, no organics were detected. The soil analytical data from the initial investigations indicated that no further soil remediation was required. Therefore, all subsequent interim remediation activities were directed solely toward ground water.

The soil cap and asphalt or concrete covers also prevent downward infiltration of rainwater. Human access to, and direct exposure to the remaining soil is not probable. The shallow aquifer has dropped several feet below the level in the original areas (1 through 8) of chemical contamination. Migration to ground water is thus unlikely. Regional flow in the shallow aquifer moves from south of the site to the northwest. An extensive array of ground-water monitoring and extraction wells covers possible flow paths away from the plant area. Ground-water monitoring results since 1985 demonstrate that no organic compounds are entering on-site ground water from these yard areas. The existing on-site monitoring and extraction wells have not detected any remaining source of soil contaminants, entering the ground water from the zones that have been remediated (Zones 3, 4 and 7) and from all the other zones (Zones 1, 2, 5, 6, and 8).

Specifically, for the soils remaining in the eight areas investigated, the potential residual risks to human health and the environment are described below:

Area 3 - Raw Material Storage

After the excavation in Phase A and Phase B and the removal of the contaminated soil, the residual soil left at the bottom of the excavated areas had the following highest observed concentrations: (in mg/kg).

	Phase A	Phase B	Drainage Ditch
Oil and Grease	2800	4100	470
Ethylbenzene	3.4	0.026	ND
Chromium	53	ND	38
Zinc	73	ND	53
Benzene	ND	0.033	ND
Xylenes	ND	0.11	ND
Methyl Cyclohexane	ND	0.22	ND

The BTX plume (Benzene, Toluene, Xylene) appeared to be confined to the section of Area 3 adjacent to the cement house. This plume appeared to be somewhat limited due to the retardation properties of the thick clay layer underlying this section. The mobility of the volatile organic compounds (benzene, toluene, xylene and ethylbenzene) in soil is controlled by several geochemical factors, such as the following:

- Sorption: by natural soil organic matter and by oil and grease
- Biodegradation: in near surface aerobic zones and also underground under anaerobic conditions
- Two-phase Flow: because of variations in density in the different media.

To conclude, the potential existence of some VOC's under the building near area 3 appears to have been limited by the low migrating capabilities of the organic components in question. If a significant amount of VOC had been left under the building it should have been detected by the active ground-water monitoring wells. But none has been observed in over five years.

The oil and grease observed in the residual soil left at the bottom of the excavation has a very low potential impact on health and environment. The same factors affecting the mobility of VOC's affect in a larger manner the mobility or migratory tendencies of the larger molecules of oil and grease. The only possible exposure to these contaminants is by dermal contact and/or by soil ingestion. The toxicity of oil and grease is very low, with a TD_{Lo} (Tumor Dose-Low) in the gm/kg range (grams of substance per kg of body weight).

According to the California Site Mitigation Decision Tree Manual (1985) the Department of Health Services (DHS) developed Applied Action Levels (AALs) criteria to evaluate and, if necessary, to mitigate the impact of uncontrolled hazardous waste sites on the public health and the environment. When soil is the medium of exposure, two routes, ingestion and dermal contact, are addressed in developing AALs. A reasonable and conservative estimate of the average daily soil ingestion is 0.15 g/day, and an estimate of the average daily soil exposure by dermal contact is 0.45g/day (Sedman, 1989).

The TD_{Lo} values for heavy oils (RTECS 1983) range from 1 to 10 g/Kg, or 70 to 700 grams per day for an adult. At an average daily exposure (ingestion plus contact) to 0.6 grams of soil, and a maximum of 6500 ppm oil and grease, the daily dose would be:

Dose = 65000 μg/g x 0.6 g/day = 39 mg/day.
This dose is 1/2000th to 1/20,000th of the reported TD_{Lo}.

Another insight into the relatively low hazard of oil and grease comes from the measured soil concentrations of polynuclear aromatics (PNA) at the facility. Generally, each sample showed two or three PNAs, at most, in concentrations of 10 to 20 ppb. Ratioing these with the maximum 65000 ppm oil and grease level found, this is about equal to 1 ppm total PNA in the oil and grease. This corresponds to 1 μg per gram of oil and grease. With the 39 mg daily dose calculated above, the average daily exposure to PNAs would be:

PNA dose = 1 μg/g x .039 g/day = 0.04 μg

A daily dose of 0.04 μg benzo(a) pyrene equivalent represents an insignificant risk to human health. This is particularly true because there is no credible scenario whereby an individual could receive a 70 year exposure to material buried under clean soil in the middle of an industrial park.

The inorganic level in the residual soil is at nominal soil background levels with the exception of zinc (Zn). This metal is present only as zinc oxide (ZnO) which is harmless. It is in fact used in medicinal preparations (zinc oxide ointment) and is classified by the Food and Drug Administration as GRAS (Generally Regarded as Safe).

Area 4 - Sludge Drying Beds

The residual soil left in the top layer removal of Area 4 show the following level of contamination (in mg/kg):

Oil and Grease	63,000
Cr	42
Pb	6
Ni	55
Zn	110
Phthalates (3)	0.112
Phenanthrene & Naphthalene	0.011
BEHP (a phthalate ester)	4.6

The same considerations given to the impact of oil and grease for Area 3 are applicable to this area.

The metals, except zinc, are at background level. Again, zinc is found in the harmless zinc oxide form.

The phthalates measured in the samples do not appear to result from Firestone's activities. The manufacture of tires did not include the use of these compounds. Phthalates are used mostly as plasticizers in the production of polyvinyl chloride (PVC) film. Soil samples were collected and placed in plastic baggies (made of PVC) and most probably were contaminated by the phthalates in the bags.

The oil and grease at Area 4, buried under one to two feet of fill, does not pose a significant threat to human health or the environment, as discussed for Area 3.

Area 7 - Waste Oil Storage/Transformer Yard

After removal of the two storage tanks and of the soil that showed discoloration, no further action was required. The residual soil left in the area has only low concentration of metals and phthalates. Again, there is no apparent risk to health.

1.5 NONBINDING PRELIMINARY ALLOCATION OF RESPONSIBILITY

Upon consideration of all the evidence, the Department of Health Services concludes that the preliminary non-binding allocation of financial responsibility in this RAP is as follows:

Firestone Tire & Rubber Company	100%

2.0 IDENTIFYING AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

The California Site Mitigation Decision Tree Manual (DHS, 1986) and the National Oil and Hazardous Substances Pollution Contingency Plan (EPA, 1985a) each require a stepped approach to identifying and screening technologies to be used for remedial action at contaminated sites. Following characterization of specific site problems and contaminant pathways, the procedures in these documents require identification of general response actions that can meet the remedial response objectives. In general, these objectives can be met by implementing any of a variety of actions. This section presents a discussion of the remedial response objectives, general response actions to satisfy these objectives, and potential technologies that can be used in implementing these actions.

2.2 REMEDIAL ACTION OBJECTIVES

2.2.1 Contaminants of Interest

As discussed in Section 3 of the RI report, six chlorinated hydrocarbons and four aromatics have been identified in the monitoring program for this site. These chemicals are as follows:

CHLORINATED HYDROCARBONS	AROMATICS
1,1-Dichchloroethane (1,1-DCA)	Benzene
1,2-Dichchloroethane (1,2-DCA)	Toluene
1,1-Dichloroethene (1,1-DCE)	Ethylbenzene
1,1,1-Trichloroethane (1,1,1-TCA)	Xylene (3 isomers)
Trichloroethene (TCE)	
Tetrachlorothene (PCE)	

However, an examination of the geochemical monitoring database for the five affected agricultural wells, the one affected domestic well, and the one affected inactive well shows that the actual chemicals of interest are fewer than this. (Affected well is used here to indicate a well where chemicals have been detected on a repeatable basis since the monitoring began.) 1,2-DCA; PCE; and the aromatics have not been repeatedly detected in any of these wells. Further TCE has not been detected in these wells, except for Harris B, since September 1986. Thus, the primary chemicals of interest are 1,1-DCA; 1,1-DCE; and 1,1,1-TCA.

2.2.2 Allowable Concentrations Based on Risk Assessment

A key finding of the risk assessment prepared for this project (IT, 1988b) is establishing ground-water concentrations that protect public health and the environment. These health-protective levels were established by back-calculating from a carcinogenic risk criterion of a one in one million (1×10^{-6}) hazard, or a noncarcinogenic index criterion of one, to a chemical concentration at a domestic-use tap. These health-protective levels and the maximum contaminant levels (MCL) respective values in µg/ℓ are as follows:

• Carcinogens	Health-Protective Levels	MCLs
- 1,2-DCA	0.5	0.5
- TCE	3.2	5
- PCE	0.7	5
- Benzene	0.8	1

	Health-Protective Levels		
• Noncarcinogens	Unfactored	Factored	MCLs
- 1,1-DCE	290	6	6
- 1,1-DCA	230	50	5
- 1,1,1-TCA	340	70	200
- Toluene	120	20	-
- Ethylbenzene	58	10	680
- Xylenes (3 isomers)	340	70	1,750

Based on the results of this site-specific risk assessment, these concentrations would be acceptable for a lifetime of daily use of the ground water. The unfactored values for noncarcinogens are total exposure values. The factored values incorporate a standard 20 percent factor for the contribution from drinking water plus, in the case of 1,1-DCE, an additional uncertainty factor of 10. These values have been rounded off.

2.2.3 Review of Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered Materials (TBCs)

CERCLA Section 121 requires selection of a remedial action that is protective of human health and the environment. EPA's approach to determining protectiveness involves a risk assessment, considering both applicable or relevant and appropriate requirements (ARAR) and To-Be-Considered (TBC) materials. CERCLA remedial actions that leave any hazardous substance, pollutant, or contaminant on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are applicable or relevant and appropriate under any Federal environmental law and State environmental or siting law that is more stringent than Federal requirements. Furthermore, many State laws give enforcement authority to agencies. These local agencies develop regulations that codify State requirements. As a result, some local regulations can also be ARARs.

The EPA Office of Solid Waste and Emergency Response (OSWER) issued Directive 9234.0-05 on July 9, 1987 and published an essentially identical document entitled "Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)" (EPA, 1987). These guidance documents address Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) requirements that remedial actions comply with ARARs of Federal and more stringent promulgated State laws. OSWER Directive 9234.1-01 "CERCLA Compliance with Other Laws, Manual, Draft Guidance" (EPA, 1988b) issued August 8, 1988, and 40 CFR Part 300, "The National Oil and Hazardous

Substances Pollution Contingency Plan, Proposed Rule" (EPA, 1988c) provided additional information on ARAR identification and compliance as well as defining to-be-considered (TBC) material.

ARARs are defined in the interim guidance document (EPA, 1987) as follows:

> Applicable requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
>
> Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

A requirement may be either one of these categories but not both. There is more discretion in the determination of relevant and appropriate requirements; it is possible for only part of a requirement to be considered relevant and appropriate in a given case. When the analysis results in a determination that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

In addition, the draft guidance manual (EPA, 1988b) and the proposed NCP rule revisions (EPA, 1988c) define To-Be-Considered materials as follows:

> To-Be-Considered Materials (TBCs) are nonpromulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances TBCs will be considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of cleanup for protection of health or the environment.
>
> ARARs will define the cleanup goals when they set an acceptable level with respect to site-specific factors. Cleanup goals for some

substances may have to be based on nonpromulgated criteria and advisories [for example, health advisories such as reference doses (RFD)] rather than on ARARs because ARARs do not exist for those substances or because an ARAR alone would not be sufficiently protective in the given circumstance, e.g., where additive effects from several chemicals are involved. In these situations, the cleanup requirements, in order to meet the cleanup goals, will not be based on ARARs alone but also on TBCs.

ARARs (and TBCs to some extent) may be classified into categories as follows, although not all ARARs will fall neatly into this classification system:

Ambient or chemical-specific requirements are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Performance, design, or other action-specific requirements are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes.

Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conductance of activities solely because they occur in special locations.

The initial step for identifying ARARs and TBCs involved reviewing appropriate lists of potential ARARs and TBCs and comparing them to the site condition and/or potential remedial activities. The NCP proposed rule (EPA, 1988c) lists examples of potential Federal and State ARARs and TBCs in 53 FR 51447 to 53 FR 51450 in the preamble section to the proposed rule. Potential ARARs and TBCs are presented and discussed in "CERCLA Compliance with Other Laws, Manual, Draft Guidance" (EPA, 1988b). Additionally, a copy of all Federal and State ARARs currently identified by the DHS was provided (DHS, 1989). These sources of information were reviewed and compiled with site-specific information to generate Tables 2-1 to 2-4. Table 2-1 presents Federal ARARs; Table 2-2 presents State and local ARARs; Table 2-3 presents Federal TBCs; and Table 2-4 presents State and local TBCs.

Contaminant-specific ARARs and TBCs were developed for the ground-water contaminants of interest observed at or near the facility as part of the Risk Assessment (IT, 1988b). Possible requirements, standards and criteria related to water quality goals for organic constituents to provide protection for human health and welfare were summarized in Table 4-2 of the Risk Assessment.

However, since that report was issued DHS revised the drinking-water action levels and the maximum contaminant levels. The revised values (as of April 1989) are shown in Table 2-5.

Examples of location-specific ARARs include floodplain and wetland regulations for modification or installation of discharge lines. National Pollutant Discharge Elimination System (NPDES) permits and the Monterey Bay Unified Air Pollution Control District (MBUAPCD) permit to operate are somewhat location oriented in that use-attainability studies for surface waters and attainment status of regional air quality have an impact on permit limitations.

Action-specific ARARs are discussed in detail in relation to alternative screening and detailed analyses in Sections 3.0 and 4.0.

2.2.4 Summary of Allowable Concentrations

The ground-water cleanup levels used in this FS/RAP are the lower of the concentrations based on the health-risk assessment, considering the cumulative health risks, and the concentrations based on the ARARs discussed in the previous two sections. In general, the concentrations based on the health-risk assessment are the lower concentrations; however, for benzene and 1,1-DCA the State drinking water action level ARARs are lower. Thus, the cleanup levels in ug/ℓ are as follows:

• Carcinogens	Clean-up Levels
- 1,2-DCA	0.5
- TCE	3.2
- PCE	0.7
- Benzene	0.7
• Noncarcinogens	
- 1,1-DCE	6
- 1,1-DCA	5
- 1,1,1-TCA	70
- Toluene	20
- Ethylbenzene	10
- Xylene	70

2.2.5 Development of Remedial Action Objectives

The remedial action objectives for the former Firestone facility operable unit are based on the current knowledge of the site and on the results of the preliminary risk assessment. The current knowledge of the site is summarized in the Remedial Investigation (IT, 1988a) as updated in the latest geochemical database, Appendix C. The Preliminary Risk Assessment (IT, 1988b) was updated in the RI. Key response objectives are as follows:

- To control migration of chemicals from the shallow aquifer into the intermediate and deep aquifers where the water is being used for agricultural and some domestic purposes
- To maintain the quality of ground water downgradient of the former Firestone facility suitable for agricultural and domestic use.

Related objectives include the following:

- To restore the quality of the shallow aquifer to meet State drinking water action levels

- To provide actions that will minimize adverse impact on the current use of the ground water in the area
- To provide actions that are consistent with the intent of current operating permits for the existing treatment plant
- To provide actions that protect the health of the workers and residents in the vicinity of the site.

2.3 GENERAL RESPONSE ACTIONS

The feasibility study procedures followed by both California and EPA specify identifying general response actions (DHS, 1986; EPA, 1988a; EPA, 1985b). From the inception of the studies at the Firestone site, the following general response action categories have been identified:

- Air pollution controls
- Surface-water controls
- Ground-water controls
- Gas migration control
- Waste removal
- Contaminated soil excavation
- Land disposal
- Temporary storage
- Control of Abeloe well contamination.

The air pollution controls apply to the airstripper at the treatment plant. These will continue throughout the use of the airstripper. The surface-water controls currently apply to the discharge from the treatment plant into the Salinas River. These controls will continue throughout the use of the treatment plan. Ground-water controls are a significant part of the ongoing interim remediation. Currently, these controls include source control by limiting the ground-water flow containing chemicals from the shallow aquifer into the intermediate zone. In addition, these controls include hydrogeologic containment of flow in the shallow aquifer.

Gas migration control was exercised when the soil-gas extraction system was operating. Currently, this is not an operable general response action. Likewise, waste removal was performed when the plant was closed but is not operable currently. Therefore, waste removal is not an operable general response action.

Contaminated soil was excavated during the early remediation efforts at the site, as discussed in the remedial investigation report. This contaminated soil was disposed of at a licensed Class I hazardous waste landfill. Currently, there is no soil excavation or land disposal from the Firestone site so these are not operable general response actions. Temporary storage of chemicals occurred when the facility was being closed. Currently, there is no temporary storage at the site associated with the Firestone operations.

The water quality in the Abeloe well initially exceeded the State drinking water action level for 1,1-DCE. However, the State and EPA subsequently reevaluated the toxicity of 1,1-DCE and raised their allowable limits. Thus, control of this water is not currently a general response action.

The current general response actions and those foreseeable in the future are used in conjunction with site-specific problems and viable pathways to focus subsequent remedial alternative evaluation. They also must be used in conjunction with the remedial action objectives and the allowable exposures based on the risk assessment and the ARARs discussed above to develop a range of treatment and containment alternatives that satisfy these criteria.

General response actions applicable to the Firestone site are as follows:

- No action
- Pumping on site
- Pumping off site
- Partial removal
- On-site (centralized) treatment
- Off-site (dispersed) treatment
- Off-site disposal.

In accordance with the September 24, 1987, letter from Firestone to DHS (Firestone Tire & Rubber Company, 1987), this feasibility study is to be focused on the chemicals in the ground water. Also, the no action alternative becomes a shutdown of the existing system rather than a "do nothing" scenario because there has already been substantial remediation.

2.4 TECHNOLOGY TYPES AND PROCESS OPTIONS

This section briefly describes technology types and process options. Physical, chemical, biological, and thermal treatment methods are summarized. Figure 2-1 presents the physical treatment methods, and Figure 2-2 presents the chemical, biological, and thermal treatment methods discussed in this section. An overview of technology process options is presented in Figure 2-3.

2.4.1 Physical Treatment Methods

2.4.1.1 Coagulation/Flocculation

The application of coagulation/flocculation involves the controlled addition of chemical agents such as alum or polymers. The action of these agents serves to create a second phase by transforming a suspension of ultrafine particles into coagulated material or flocs of larger particles (Berkowitz et al, 1978, page 503). The flocs may then be easily separated by gravity, thickening, skimming, filtration, or centrifugation. This technology is suitable for treatment of waste streams containing suspended solids.

Coagulation/flocculation would not be an effective treatment method for the low concentrations of organic constituents found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.2 Oil-Water Separation

Oil-water separation technology combines chemical addition, temperature control, and a variety of engineered vessel designs to enhance oil-water separation. Separator vessel designs may be a series of baffled chambers

(American Petroleum Institute-type), or a single vessel that is heated and mildly agitated. Coalescers are vessels with plates or packing to enhance the collection and recovery of ultrafine oil particles. Chemical addition and pH adjustment are frequently used in addition to aid in separation, to speed coalescing action, or to aid in breaking down of emulsions that may form. Heating may be performed to reduce viscosity and enhance the separation of emulsions.

Free oil product may be removed from the separator by manual skimming with a pump or vacuum truck. Wicking ropes or belts are often used for continuous skimming of surface oil from separator tanks or basins. Simply allowing gravity overflow of accumulated oil may be the most convenient way to remove the free product from a separator. Oil-water separation technology is only effective for separation and removal of free organic product, emulsified product, or dissolved product when concentrations are at or near saturation.

Oil-water separation would not be effective for treating the low concentrations of synthetic organics found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.3 Flotation

Flotation is a technology that has been developed primarily for the separation and concentration of mineral ores (Berkowitz et al., 1978, pp. 535-536). This technology involves the controlled dispersion of a fine air stream through a slurry. The air bubbles attach themselves to suspended solid particles (in the case of mining, preferentially to ore particles). The bubbles rise to the surface where a floc forms. A raking device skims the surface of the flotation tank, removing the accumulated floc. The floc is then collected for further processing or disposal. The aqueous phase is decanted, disposed, or recycled. The process usually operates in a continucus mode. Waste treatment applications have included cardboard fiber reclaiming, municipal sludge thickening, and water clarification. This technology is only applicable to the separation of slurries (two phases).

Flotation would not be effective in treating the low concentrations of dissolved synthetic organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.4 Media Filtration

This technology involves passing a contaminated waste stream through a fixed (stationary) matrix (such as sand, dolomite, or fabric), which provides relatively uniform pores for physical trapping or retention of a portion (particulate phase) of the waste stream. Media filtration, as referenced in this section, applies to matrices providing pore diameters greater than one micron. Media filtration does not include media that have adsorptive capability such as activated carbon, zeolites, ion exchange resins, or oil-adsorbing media. Chemically active or reactive media, such as stationary catalyst beds or fixed stationary enzymes, are also excluded since their primary function is not to provide a barrier but to perform a chemical transformation. Membrane-type treatment technologies, such as reverse osmosis, are also not included under Media Filtration. These methods are referenced in other sections (refer to Section 2.4.1.7, Reverse Osmosis; Section 2.4.1.8, Dialysis; Section 2.4.1.9, Electrodialysis; Section 2.4.1.10, Ultrafiltration). Media filtration is only capable of removing contaminants greater than one micron in size. This technology is not effective in removing molecular contaminants such as synthetic organics.

Media filtration would be ineffective for treatment or removal of the chemicals found in the Firestone Salinas ground water. However, the technology could be appropriate for pretreatment to remove suspended solids, silts, and clays that may be in the ground water pumped to the surface. No further consideration will be given to this method for implementation as a primary treatment method at the Firestone Salinas site. Pretreatment of Firestone Salinas ground water has not been required to date. All extraction wells have been thoroughly developed to minimize intrusion from suspended solids.

2.4.1.5 Absorption/Adsorption

The two categories of absorption/adsorption (Northwestern Carbon, 1988) are physical adsorption and chemisorption. These two processes will be discussed separately.

These two processes will be discussed separately.

Physical Adsorption

Physical adsorption is a surface phenomenon involving weak van der Waals forces, differing from absorption, which by definition is penetration of one substance into the bulk of another (Weist, 1975). The forces involved in physical adsorption are similar to those responsible for surface tension in liquids. Physical adsorption as referenced in this section takes place between a solid adsorbent and a liquid or gas containing adsorbable species. (Liquid-liquid absorption is discussed in Section 2.4.1.13.) Adsorbents possess a very high internal surface area which provides the sites for adsorption to take place (at the molecular level). Adsorption is a reversible process because of the weak van der Waals forces involved. Adsorbents can be regenerated using solvents, steam, heat, or other methods depending on the species that is adsorbed. There are many different useful adsorbents used in chemical processing and waste treatment; these include acid-treated clay, activated alumina, alumino silicates, bone char, Fullers earth, iron oxide, magnesia, silica gel, and carbon (Mark et al., 1985). Clays are most commonly used as oil adsorbents. They are particularly effective against free oil or micro emulsions, for which activated carbon would be ineffective, rapidly depleted, or uneconomical. Often clays are used as a pretreatment of the feed to a carbon system. The other adsorbents listed have limited use in waste treatment applications, except for iron oxide. The application of iron oxide in waste treatment is discussed in more detail in Section 2.4.2.5 under Electrolytic Oxidation/Reduction.

Activated carbon adsorption is the primary adsorbent used in waste treatment today. The following technologies use activated carbon:

- Granular Activated Carbon Treatment (GAC)
- Powdered Activated Carbon Treatment PACT™ (PACT™ is a registered trademark of Zimpro Corporation).

These methods will be discussed individually.

Granular Activated Carbon Treatment

Carbonaceous, material such as coal, wood, coconut shells, or petroleum pitch, when subjected to controlled oxidation (in a kiln) under a reducing atmosphere, can be "activated," producing a high quality, effective adsorbent. The activation process serves to burn out some of the carbon, creating an intricate internal structure within the carbon matrix. The internal structure is characterized by a very high internal surface area. High grade activated carbons have over 1,000 square meters of internal surface area per gram. An in-depth discussion of the concepts of activated carbon adsorption may be found in Appendix D.

Granular activated carbon treatment is one of the preferred methods for economical removal of low concentrations of a wide variety of small to medium size organic molecules. Larger molecules (such as oil) are not as readily adsorbed because these molecules do not fit well into the internal pores of the activated carbon (the pore sites being where adsorption occurs). Small molecules, however, diffuse readily into the pores and are held by the weak, attractive van der Waals forces. Different compounds are adsorbed more readily than others. This scale depends on a variety of factors including molecular size, structure, the carbon type and pore size, and the heat (or energy) of adsorption. The heat of adsorption is generally equivalent to the heat of condensation (gas to liquid phase change) of the adsorbed species. Experimentally measured adsorption capacities have been determined for various compounds. A summary of the test procedures to determine carbon adsorption capacities and a summary of carbon adsorption capacities for a variety of chemicals are provided in Appendix E.

Granular activated carbon treatment is most economical for removing low concentrations of organics. The higher the influent waste concentration, the more quickly the carbon is exhausted. Waste streams containing organic concentrations up to 100 ppm can be economically treated using activated carbon. Streams up to 10,000 ppm can be economically treated, provided regeneration of the carbon in place is possible. Vapor-phase solvent recovery using activated carbon is one application where activated carbon is used for treatment of high concentrations of organics. The activated carbon is usually steam regenerated and the solvent recovered by decanting or distillation. Vapor-phase organic adsorption on activated carbon has to be carefully monitored to prevent bed fires resulting from the heat evolved by adsorption.

Activated carbon treatment is technically appropriate for treating the ground water at the Firestone Salinas site. Carbon is especially well suited for removing the very low concentrations of chlorinated organics and producing a very high purity effluent stream. Further evaluation will be performed on this method in combination with other options in Section 3.0.

PACT™

Powdered activated carbon treatment is a process that uses pulverized activated carbon in conjunction with biological treatment to produce very high reductions of biological oxygen demand (BOD) (99%) and chemical oxygen demand (COD) (90%). PACT™ reduces odor and toxicity and improves effluent color over conventional waste-treatment processes (Zimpro, 1984). PACT™ is a process licensed to Zimpro Inc.

PACT™ treatment involves addition of powdered carbon to the effluent of a primary clarifier in a waste treatment plant. The mix is sent to an aerated basin where further biological action takes place and toxics are adsorbed onto the carbon. The effluent from the basin flows to a secondary clarifier where the carbon and sludge are settled out and removed from the bottom of the clarifier. The carbon is recovered, regenerated, and sent back to the clarifier. Sludges are separated and further treated or disposed. The overflow from the secondary clarifier is ready for discharge or may be filtered to remove any trace carryover solids. Carbon recovery is in the 80 to 90 percent range. The process is effective in removing low levels of industrial organic wastes and solvents that find their way into municipal waste streams (Zimpro, 1984).

The process is somewhat capital intensive and is generally intended for large-scale waste-treatment operations treating greater than 1 million gallons of wastewater per day.

PACT™ technology would not be appropriate for treatment of the Firestone Salinas ground water. Since granular activated carbon treatment alone has proved to be adequate, the capital cost for the additional combined biological treatment capability provided by PACT™ would not be justified (since biological treatment is only marginally effective against chlorinated organic hydrocarbons). Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Chemisorption

Chemisorption is primarily an absorption process using chemicals, solvents, or chemically treated media to absorb materials from a waste stream. The process relies on solvation or chemical reaction and the formation of strong chemical bonds as compared to the weak forces driving physical adsorption processes. Chemisorption processes may proceed by adsorption at the surface interface then absorbed as reactions and diffusion into the bulk mass takes place.

Chemisorption processes are not as easily reversed as physical adsorption processes, especially if the bonds formed are extremely strong. Examples of chemisorption in waste treatment are the use of limestone or sodium carbonate to remove sulfur dioxide from stack gases. Anhydrous materials such as copper sulfate or concentrated sulfuric acid are used as chemical agents to remove water from gas streams. In refinery processing, alkanolamines are used in sour gas scrubbing towers to remove carbon dioxide, hydrogen sulfide, and carbon disulfide from sour refinery gas (Dow Chemical Company, 1980).

Chemisorption would be ineffective in treatment or removal of the chlorinated organics in the Firestone ground water. Chlorinated organics are relatively inert and nonreactive. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.6 Gas-Phase Stripping

The three gas-phase stripping processes that have application to waste treatment are as follows:

- Air stripping
- Steam stripping
- Alternate gas stripping.

These three processes are discussed in the following subsections.

Air Stripping

Air stripping is a commonly used method for removal of volatile organics from water. Air stripping, similar to distillation, is a mass transfer process that depends on the favorable equilibrium for the transfer of dissolved volatile components from the liquid into the gas phase. A variety of different methods can be used to enhance the mass transfer rate such as spraying (spray ponds), aeration towers (with plates), or packed stripper columns. The purpose of spraying, plates, or packing is to enhance mass transfer by providing intimate contact between the air and liquid (the same function plates perform in a distillation tower). The volatile components in the liquid will transfer to the gas phase, providing a continuous supply of fresh, uncontaminated air is kept in contact with the liquid (Kavanaughy, 1980).

Packed stripper columns have advantages over other enhanced air stripping methods. Packed columns provide multiple equilibrium stages giving the highest mass transfer efficiency. Forced air draft in a stripper column can be adjusted to provide the optimum air-liquid ratios for removal of particular volatile chemical species. Packed columns can also be used to perform pretreatment before another operation such as activated carbon adsorption.

The advantages of air stripping in waste treatment are the low treatment cost, high efficiency for volatile organic removal, simple operation, and compactness for treatment of large volumes. Air strippers for ground-water treatment are most economical in locations where direct discharge to the atmosphere is allowable.

Air stripping is a treatment method that has been proven efficient and cost effective in removing volatile organic contamination in ground water (Shukla and Hicks, 1984). The removal of the chlorinated organic hydrocarbons in the Firestone Salinas ground water by air stripping has been demonstrated as a very effective treatment method. Air stripping will be evaluated further in Section 3.0 as a suitable treatment method for implementation of the Firestone Salinas site.

Steam Stripping

Steam stripping is a waste treatment method using saturated steam injected in a liquid stream to remove volatile components. The same general mass transfer principles apply to steam stripping as for air stripping.

Steam stripping is confined within closed tanks or columns to control heat transfer losses. A closed tank with a steam sparger will serve as a single-staged steam stripper. Columns with plates or packing provide multiple equilibrium stages greatly increasing efficiency. The primary advantage of steam stripping is the operation at higher temperature (of the saturated steam) increases the vapor pressure of volatile organic contaminants and decreases the solubility of dissolved gases in the liquid phase. In addition, pH adjustment may be used to further decrease the solubility of certain acid or basic gases such as ammonia or hydrogen sulfide. This method provides extremely high removal efficiencies for many organics, including many which are not easily removed by simple air stripping.

The major disadvantage of steam stripping is energy consumption. The feed must be preheated to near the temperature of the saturated steam. The high heat capacity of aqueous solutions becomes a major economic concern when comparing energy and capital costs of competitive treatment processes.

Steam stripping would be effective in removing the organic contamination in the Firestone Salinas ground water. However, it has been demonstrated that air stripping is an effective treatment method. The added cost of using steam would provide no additional benefit. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Alternate Gas Stripping

Alternate gas stripping is gas phase stripping of waste-containing liquids using a supplied gas other than air or steam. Gases used may include carbon dioxide or nitrogen. This method of stripping might be used when air would form flammable or explosive mixtures with the waste material (thus requiring an inert atmosphere for safety). Use of an alternate gas for stripping might also be appropriate when the energy economics of using steam stripping prevent its use as an inerting agent (steam is an effective oxygen stripper). An inert gas may also be required when the materials involved require inerting but are heat or water sensitive (eliminating the option of using steam).

Alternate gas stripping might be used economically when a chemical reaction with the gas aids stripping efficiency, such as using carbon dioxide to strip and acidify a waste stream.

Alternate gas stripping would be effective in removal of the organic contaminants in the Firestone Salinas ground water. However, there is no additional benefit to offset the added cost of supplying an inert alternate gas. Simple air stripping has proven safe and effective for removing the chlorinated organic hydrocarbon contamination. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.7 Reverse Osmosis

Reverse osmosis technology employs a semipermeable membrane to achieve ionic size separations. The membrane is maintained under a sizable pressure gradient to achieve concentration of dissolved organic and inorganic species. Influent is pumped to the reverse osmosis unit at a pressure of between 300 and 600 psi. Flow is maintained tangential to the membrane surface by using a tubular configuration to support the membrane. As a result of continuous flushing (due to tangential flow), the membrane does not become plugged as does a media filter (which has flow normal to the media).

Reverse osmosis treatment generates two streams, a clean permeant and a concentrated reject stream. Reverse osmosis treatment does not destroy or eliminate contaminants but concentrates them in the reject stream. The reject stream must then be further treated or disposed. The generation of the reject stream may be a drawback of implementing this treatment method. Concentration of the waste stream up to 75 percent is possible in one pass. Multiple units in series are able to further concentrate the waste stream; however, there are limits that affect the performance and integrity of the reverse osmosis membrane. Reverse osmosis can be used for producing very concentrated streams when combined with other technologies such as distillation. The reverse osmosis process cannot tolerate suspended solids, requiring pretreatment to prevent membrane fouling or damage. Membranes are also susceptible to chemical attack, fouling, and damage from other species including oil, grease, iron and manganese salts, particulates, and bioorganics (such as algae) (Berkowitz et al., 1978, page 834). Volatile organics may cause membrane swelling and permanent damage to the reverse osmosis membranes.

Capital costs are high for large capacity systems, the major cost item being the membranes themselves. Energy consumption is low to moderate. The major energy requirement is to drive the high pressure feed pump. Reverse osmosis is more economical for concentrating dilute streams than evaporation or distillation.

Reverse osmosis is an unsuitable treatment method for the Firestone Salinas ground water due to the potential membrane damage that may occur from treating chlorinated synthetic organics. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.8 Dialysis

Dialysis is another membrane separation technology. The membranes used are semipermeable, which allow salts and small organic molecules to pass freely through while higher molecular weight species are retained (concentrated). The process relies on simple diffusion with the concentration gradient across the membrane as the driving force.

Dialysis is best suited for use in treatment of concentrated solutions (5 to 20 percent). Also, the membranes can be sensitive to solvents, which may cause them to swell or degrade. The best applications of this method are for purification of caustic or nonoxidizing acid solutions containing low molecular weight organics. The production rate of dialysis is relatively low compared to other methods (Berkowitz et al., 1978, pp. 347 and 349). Dialysis generates a concentrated reject stream that may require further handling or

Dialysis would be ineffective for treatment or removing the low concentrations of organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.9 Electrodialysis

Electrodialysis uses ion-exchange-type membranes to separate ion-containing solutions into dilute and concentrated streams by application of a dc electric current across a selectively permeable membrane. The membranes are permeable to only one type of ion charge (anions or cations). Application of a current causes ions to migrate toward the respective anode or cathode. Blocked by the selectively permeable membrane, ionic species concentrate on one side of the membrane or the other. The method is totally ineffective for nonionized or noncharged species. Also the most effective and productive operating range is for solutions whose ionic concentration is between 200 and 5,000 ppm (Berkowitz et al., 1978, pp. 406-407).

Electrodialysis would be ineffective for treating the low concentrations of organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.10 Ultrafiltration

This technology employs a porous membrane that behaves similar to a fixed- or stationary-media filter. A pressure gradient of 10 to 100 psi is maintained across the membrane, producing a concentrated reject and dilute permeate stream. The pore sizes of ultrafiltration membranes are much smaller than typical media-type filters. Ultrafiltration membranes will retain large molecules (greater than 1,000 molecular weight), colloids, and suspended solids while allowing water molecules, ions, and small organic molecules to pass through. Membranes can be tailored to specific applications (pore sizes) such as removal of viruses or higher molecular weight organics in the 10 to 1,000 Angstrom range (Berkowitz et al., 1978, page 899). This method generates a concentrated waste stream that may require additional handling or treatment (typical of all membrane separation technologies). The membranes are generally not restrictive to low molecular weight organics, and the membranes may be sensitive to chlorinated synthetic organic solvents (which may cause swelling or degradation).

Ultrafiltration would be ineffective for treatment or removal of the low levels of chlorinated organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.11 Freeze Processing

The following methods of freeze processing may have application to waste treatment:

- Freeze crystallization
- Freeze crying
- Suspension freezing
- Zone refining.

Each of these is discussed in the following subsections.

Freeze Crystallization

This treatment method relies on the phase change that occurs when mixtures containing dissolved solids are frozen. The crystals that first form as a solution is cooled are pure relative to the remaining liquid. These pure crystals may then be removed mechanically, washed, and recovered. The remaining solution is now concentrated with the undesired impurities. The method is most effective for treating solutions containing a 1 to 10 percent concentration of dissolved species. The only commercial application of this technology is for producing fresh water from salt water.

The disadvantages of this method are high energy consumption (as a result of requiring refrigeration), removing, washing, and handling the frozen product, and the high concentration range required to be effective (Berkowitz et al., 1978, pp. 552-553).

Freeze crystallization would be ineffective for treating the low-level organic contamination in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Freeze Drying

Freeze drying is a process for removing water and volatiles from aqueous mixtures containing solids or dissolved solids. The process involves freezing the mixture, then pulling a high vacuum to sublime the water and remove any volatiles. The remaining solid material is essentially dry without having to be subjected to any heat. This method may have value in dewatering chemically sensitive materials. This process is used commercially to produce freeze dried coffee and other dried foodstuffs. Avoiding the use of heat to recover food products prevents thermal degradation and preserves flavor. The freeze drying process might be applied to the dewatering sludges; however, the added cost of providing the necessary refrigeration usually prevents its use in favor of other more economical methods.

Freeze drying would not be a cost-effective treatment method for the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for the implementation at the Firestone Salinas site.

Suspension Freezing

It has been observed that the freezing and thawing of some sludges and gelatinous materials aid in the agglomeration and separation of solids. The freezing causes suspended solids to floc, and when thawing occurs, the floc separates from the solution. The effect is believed to be as a result of pressure exerted on sludge particles by the formation of ice crystals. This treatment has been found to be effective on all types of municipal treatment plant sludges. However, this process has only been demonstrated in the laboratory. The requirement for refrigeration would probably make it competitive only in climates where winter temperatures provide natural refrigeration.

Suspension freezing would not be an effective method for treatment or removal of dissolved organics in the Firestone Salinas ground water. The process has only been demonstrated effective for the separation of sludges. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Zone Refining

Zone refining is a melt/refreeze method used to produce ultrapure metals, inorganics, and organic materials. It is costly and only suitable for treatment of small batches of material. The principal of zone refining is phase equilibrium, similar to freeze crystallization or distillation. When a melted mixture cools, the crystals that form have a composition different from the original mixture. The solid phase is enriched with the less volatile components, opposite of distillation where the vapor phase is enriched with the more volatile components. The process is usually applied to already pure materials. A rod of material is passed through a heater (usually inductive heating for metals). The heater melts a small portion or zone in the rod. As the rod is moved forward through the heater, the molten zone moves down the length of the rod. The impurities tend to stay in and be carried by the molten zone. Repeating the process a number of times results in the production of an ultrapure rod. This technique has use in the high technology and semiconductor industries where ultrapure materials are required and the cost is justified. There are no viable applications for waste or hazardous waste treatment due to the economics (Berkowitz et al., 1978, pp. 910-916).

Zone refining is not applicable to waste treatment or ground-water treatment. Thus, no further consideration will be given to this method for implementation at the Firestone Salinas site.

2.4.1.12 Distillation

Distillation is a well known technology for separating mixtures of pure liquid components. The method relies on the difference in volatilities of the components of a mixture and the equilibrium those components reach in the vapor phase at varying temperatures. Heating a mixture enriches the vapor phase with the more volatile component. Condensing this vapor phase produces a volatile-rich liquid. Repeating this process in a multistaged distillation column allows for separation of components that may have only slight differences in boiling point (although this may require a large number of equilibrium stages). Distillation is best suited when concentration of the feed to a nominal purity is acceptable. Production of ultrapure distillate or highly concentrated bottom material may require several hundred equilibrium stages, high reflux rates and large columns. This results in high capital cost and high energy consumption when large feed volumes must be handled. Also, distillation of aqueous solutions is especially energy intensive due to the high heat capacity of water.

Distillation would be effective but uneconomical for treatment of the low concentrations of organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas Site.

2.4.1.13 Extraction

The following five types of extraction methods have application to waste treatment:

- Liquid-liquid extraction (referred to as solvent extraction)
- Liquid-solid extraction (referred to as leaching)

- Liquified gas extraction
- Supercritical fluid extraction (referred to as supercritical fluid oxidation)
- Gas-liquid extraction (referred to as stripping).

The first three of these methods are discussed in more detail below. The latter two of these methods are discussed in Sections 2.4.1.6, Gas-Phase Stripping, and 2.4.2.4, Oxidation.

Liquid-Liquid/Solvent Extraction

Solvent extraction technology uses an immiscible solvent in contact with a second solvent containing a dissolved species (solute) that is to be recovered. An immiscible solvent is selected that has a great affinity for the solute. Intimate contact induced by vigorous agitation or in a designed, staged contactor allows for the transfer of the solute from one solvent to the other based on favorable equilibrium. After contact, the two immiscible solvent phases separate, allowing for recovery of the solute and either reuse or disposal of both solvents. The major advantage of this method is that, with the proper choice of an extraction solvent, only a relatively small volume of extraction solvent is required to recover the solute from a very large volume of influent. This process can be significantly more energy efficient than direct recovery by methods such as distillation. Proper application of solvent extraction technology concentrates the solute, often by orders of magnitude, with very low energy expenditure.

The major inherent problem with this technology for environmental applications is finding an extraction solvent that is not in itself environmentally sensitive. Organic solvents that are immiscible with water are all slightly water soluble to some degree. This contamination may make return of treated ground water or wastewater to the environment impossible without additional treatment.

The potential environmental concerns associated with liquid-liquid extraction and the availability of much more acceptable and effective technologies make this method unsuitable to treat the low levels of organic contamination in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Liquid-Solid Extraction/Leaching

The two types of leaching mechanisms are solvation and chemical reaction. Since these two methods are applied identically, they will be discussed together.

The following are the four types of leaching processes:

- Batch
- Continuous
- Heap or pile
- In situ (solution mining).

All these processes involve contacting a liquid with a solid, resulting in the selective removal of a portion of the solid material, either by solvation or chemical reaction.

To differentiate between solvation leaching and chemical leaching, an example of each is given. The leaching of coffee with water is an example of solvent leaching. Certain coffee solids and oils are solvated (dissolved) by the water, producing the extracted cup of coffee. Alternatively, the leaching of gold from ore using mercury metal is an example of chemical leaching. The mercury chemically reacts with the pure gold particles in the ore to form an amalgam.

There are many different arrangements of batch and continuous leaching equipment, processes, and vessels. Leaching may be performed in a single tank or vessel with an agitator to mix the solids and leaching liquids. A continuous multi-staged extraction system may be used to increase efficiency and yield by providing multiple recovery stages, reflex of leachate liquid, filters, settlers, etc. Extraction, being an equilibrium process, is governed by fundamental mass-transfer principles, the same as distillation and air stripping.

Heap leaching is a common method used in mining. Large mounds of ore are placed on an impervious surface such as clay, a concrete slab, or plastic lining. Leaching liquid sprayed on the mound percolates through the solid mass. The enriched leachate is recovered at the bottom of the mound and processed to recover the desirable material. This method is sometimes used in waste treatment to treat contaminated soils. An example of heap leaching is the treatment of cyanide-leached ore piles (formerly leached for gold and silver) which have been left with residual cyanide. Solutions of oxidizing agents are sprayed on the contaminated mound, chemically leaching out the cyanide as cyanate or allowing the reaction to go to completion, producing carbon dioxide.

In situ leaching is generally referred to as solution mining. Leaching liquids are pumped underground into an ore body. The desirable material dissolves or reacts with the liquid. A second recovery well allows the leaching liquid to return to the surface where it can be processed to recover the leached material.

The advantage of solution mining is avoiding the cost and hazards involved with underground mining. The disadvantages are environmental concerns over injecting liquids into the ground water and insoluble contaminants in the ore body, which may decrease the yield of the leaching process. These insoluble contaminants can become a significant barrier to mass transfer when they accumulate. Potential waste treatment applications might involve the removal of metals or organics from sludges or soil using an appropriate liquid extractant.

Liquid-solid extraction would not be effective for treating or removing the dissolved organic contamination in the Firestone Salinas ground water. Thus, no future consideration will be given to this treatment technology for implementation at the Firestone Salinas site.

Liquified Gas Extraction

Liquified gas extraction (LGE) is a process that can be effective in removing organics from liquid waste streams. The principles are similar to liquid-liquid extraction except the solvent is a gas liquified under pressure. Liquified gases such as carbon dioxide and propane have the ability to extract many organics. Liquified gas extraction is usually carried out in multi-staged columns providing high extraction efficiencies. The process operates based on the equilibrium between the solute and liquified gas solvent. It is controlled by mass-transfer principles similar to distillation, air stripping, and liquid-liquid extraction. Extraction using a liquified gas generates two waste streams, an organic fraction (dissolved in the liquified gas) and an inorganic fraction usually consisting of solids, salts, and water. These two streams are immiscible. The organic dissolved by the liquified gas can be recovered by separating the phases, then relieving the pressure on the gas. The liquified gas, usually having a substantial vapor pressure difference compared to the dissolved organics, flashes off, leaving the extracted organic contaminants behind. The gas can be collected, recompressed, and reused (Hazardous Material Control, 1988).

This process may have energy advantages over nonpressurized solvent extraction processes. The energy required to recompress the gas may be less than the energy necessary to distill off solvent, as might be required by conventional liquid-liquid extraction processes to recover the extracted organic. However, this economic advantage may be offset due to the added capital cost of pressurized vessels and a compressor.

Liquified gas extraction could probably be effective in treating the Firestone Salinas ground water. However, this method would be capital intensive to implement as a treatment method for removing the organic contamination. Development and testing would be required to verify the suitability of a liquified gas extraction solvent and determine proper operating conditions. Also, gas, liquid extraction (air stripping) has been demonstrated as an effective and economical treatment method. The developmental expense and greater capital costs in Liquified Gas Extraction are not justified. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.14 Mechanical Separation/Treatment

Mechanical separation is the separation of materials using mechanical-type equipment. The following are the most common mechanical units used in waste treatment:

- Centrifuges
- Belt filter presses
- Air classifiers
- Vibrating screens
- Shredders/grinders
- Hydroclones.

Each of these is discussed in the following subsections.

Centrifuges

The settling out of solids in a tank or basin due to gravity is a well known occurrence. Often settling occurs in chemical processing, and agitation is required to keep solids in suspension or a mixture homogeneous. The opposite situation can also be a problem when suspended solids are so fine or emulsified that normal gravitational force has no effect on settling them out.

Mechanical centrifuges can increase the apparent force on solids in suspension up to 300,000 times normal gravitational force (g) depending on the type of centrifuge. Centrifuges may operate in batch or continuous mode depending on the design. The centrifuges that produce the highest g forces (greater than about 15,000g) are generally batch type and only suited for pilot or laboratory operations.

The most widely used centrifuge in waste treatment is the continuous decanter centrifuge operating in the range of 2,000 to 5,000g (Moir, 1988). The unit has a rotating outer bowl with an inner backdrive scroll (similar to a screw feeder). The slurry is fed up the hollow shaft of the scroll, which rotates at a faster speed than the bowl. The feed moves through the ports on the shaft into the bowl, where the solids form a layer. The liquid depth in the bowl is controlled by adjustment of ports at the liquid discharge (centrate) end of the unit. Solids are conveyed away from the liquid end of the centrifuge by the scroll (hence the name backdrive). They are drawn into the conical end of the bowl and discharged at the opposite end from the liquid. Polymers are frequently added to enhance separation and produce a drier cake (Moir, 1988). Continuous centrifuges are only suitable for treating wastes containing contaminants greater than one micron in size.

A centrifuge would not be effective for the treatment or removal of the low-level organic contamination in the Firestone Salinas ground water. Thus, no future consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Belt Filter Press

The belt filter press is a mechanical unit which uses two continuous porous belts to dewater fibrous organic solids in the 1- to 2-percent solids range. The two belts run in a continuous loop over a series of rollers. The waste liquid is introduced onto one belt, which allows free water to drain by gravity. The waste then travels on the top belt to a point where the top belt meets the bottom belt at a point called the wedge zone. The two belts move together in a wedge-shape configuration, applying greater and greater pressure to the waste solid (removing more and more water) trapped between the belts. The two belts then move to the pressure zone over and around a series of hydraulic rollers where the pressure on the waste between the two belts is highest (up to 100 psi). After the pressure zone, the two belts separate and the dry solids drop by gravity into a bin or onto a conveyor belt for loading or disposal.

Applications of a belt filter press to waste treatment include dewatering of municipal waste sludge and reclaiming of waste cardboard fiber. Polymers are often added to coagulate the waste, improve removal efficiency, and produce a drier cake. This treatment method is effective for removing solids greater than 500 microns (Deutsch, 1987).

A belt filter press would be ineffective in treatment or removal of the low-level synthetic organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Air Classifiers

Air classifiers are devices that separate solid materials based on size. A number of forces act on particles carried by an air stream, such as gravity, drag, and centrifugal force (if the air stream and particles are rotating). The simplest form of an air classifier is a cyclone separator that simply removes particulates from gas streams. The particulate-laden gas stream enters the cyclone chamber. The chamber is a cylindrical vessel with a cone bottom. The gas stream is directed tangentally along the cylindrical surface causing the gas to spin around the cylinder. The particles are moved outward as a result of centrifugal force. Particulates begin to fall as gravity acts upon them. When they fall near the bottom, they enter the cone portion of the chamber. The decreasing diameter of the cone accelerates the air stream, increasing the centrifugal force on particulates and increasing the air pressure in the bottom of the cone. The particulates fall out the bottom of the cyclone (carried by a small amount of gas). The cleaned gas exits the top of the cyclone through a large center exhaust nozzle (due to lower air pressure at the top of the cyclone). This process is limited to removal of medium to large particulates. Small particulates are entrained in the gas phase and are carried out the top of the cyclone.

Air classifiers make use of drag on a particle in a gas stream as a function of surface area, volume, density, and gravity to separate (classify) particulates and solids by size. There are numerous commercial air classifying units available varying in design and configuration (Klumpar et al., 1986). Air classifiers are useful for grading solid feeds or products by size, which may be critical to the efficiency of a chemical process or the sale of manufactured materials. The details of the many available commercial air classification units will not be discussed further for the purpose of brevity. The primary application of this technology to waste treatment is dust or particulate removal from process gas streams or stack emissions.

Air classification would not be effective for the treatment or removal of the dissolved organic contamination in the Firestone Salinas ground water. Thus, no further consideration will be given to this method for treatment of ground water at Firestone Salinas.

Vibrating Screens

This method is used to classify dry solids by size or separate water from wet solids using gravity. A descending order series of large surface area screen trays, each with a different size opening, are fed a dry solid stream or a wet slurry. The stream cascades down through the series of screens, being rejected off a side opening in the screen tray if the particle size is too large to pass further. Sorted reject particles are collected by screen size. Each size collected actually is representative of a range of sizes based on the individual screen characteristics, ranges, and openings. The screens are energetically vibrated to keep the particles in motion and prevent plugging.

Vibrating screens are only effective for particulate removal, classification, or recovery. A vibrating screen would not be effective for treatment or removal of dissolved organic contaminants as found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Shredders/Grinders

Shredders, grinders, mazorators, choppers, and a host of other units are used to precondition waste streams to enhance treatment or simplify disposal. Large solids are a problem for many processes. Plugging of pipelines, agglomeration, and overloading or jamming equipment are all problems associated by oversized or poorly conditioned feed. Sanitary treatment plants frequently grind all influent feed to prevent line plugging and enhance biological degradation of solids by maximizing surface area. Wood, brush, leaves, and trash are often chipped or shredded at sanitary landfills to enhance compaction and biological degradation of waste materials. Trash or tires are often shredded prior to burning in incinerators so a uniform feed is provided and process control problems are minimized. Coal is pulverized to a uniform fine powder for feed to power plant boilers. Automobiles, appliances, and other objects are often shredded at reclaim sites to aid the magnetic separation of iron from other materials.

Shredders or grinders would not provide any benefit toward the conditioning of contaminated ground water at Firestone Salinas for treatment or removal of dissolved organic contamination. Thus, no further consideration will be given to this pretreatment method for implementation at the Firestone Salinas site.

Hydroclones

Hydroclones are liquid-phase versions of cyclone separators. The vessel design and configuration is very similar and the functional mechanics and process are the same. A liquid feed containing suspended solids enters the hydroclone. As in a cyclone, the feed is directed tangentially to the outside of the hydroclone cylinder wall. The spinning of the liquid around the hydroclone causes solids to move outward as a result of centrifugal force. The solids drop downward as a result of gravity. Solids concentrate in the cone bottom, and are discharged out the bottom as a slurry. Clear liquid exits overhead. The disadvantage of hydroclone treatment is due to entrainment. Only medium to large particles are removed. Also, the collected solids are still very wet and require further drying before disposal. The primary advantage is cost. It is a very cheap separation method, requiring only energy from pumping the fluid through the unit. Variations on hydroclones allow for size classification of the solids, similar to gas-phase air classifiers.

Hydroclones are suitable for particulate phase removal only. The technology would not be effective in treatment or removal of the dissolved organic contamination found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.15 Magnetic Separation

This treatment method is suitable for separation of paramagnetic materials. The two magnetic processes having potential applications in waste treatment are magnetic conditioning and high gradient magnetic separation. Each of these is discussed in the following subsections.

Magnetic Conditioning

This method is primarily used for gross removal of tramp iron from a wide variety of processes. It has application to mining, metal reclaiming, chemical processing, and other process where free iron needs to be removed. Magnetic conditioning is used to protect conveyor belts or sorting areas where materials pass by. Powerful magnets are suspended to attract any free iron contaminants or objects such as tools, nails, steel objects, etc. This is usually done to reclaim the objects or prevent damage further down the processing line to other units (such as rock crushers).

Large electromagnetic cranes are used in salvage yards to scavage free iron from other shredded materials such as plastic or rubber.

Magnetic conditioning would be totally ineffective in removing or treating the dissolved organic contaminants in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

High-Gradient Magnetic Separation

This treatment method uses very high intensity magnetic fields to affect separations based on ferromagnetic, paramagnetic, or diamagnetic properties of the component elements. All but 16 elements exhibit one of these three properties. The high-grade magnetic separation process (HGMS) requires a high energy electromagnetic source and a ferromagnetic filament, which may be felted or woven steel-wool expanded metal, or some similar type of iron material providing a high void space. Magnetic fields up to 20,000 Gauss are necessary for treatment to be effective. The waste stream is passed through the ferromagnetic filament filter. Under applied magnetic fields, impurities are collected in the filter due to magnetic attraction. When the filter becomes loaded, the magnetic field is turned off and the filter fabric decontaminated. HGMS is effective in removing particles as small as one micron.

Various configurations are possible to allow for cyclic or continuous operation. Superconductivity magnets show promise by providing even higher magnetic fields. There are many potential applications for this technology, but most are in the developmental stage. Iron ore concentration using HGMS technology has been commercially demonstrated. Other possible applications include water treatment and other types of pollution control. The method can be effective in removing nonmagnetic species, providing they can be trapped in an iron matrix such as iron oxide (Klumpar et al., 1986).

High-gradient magnetic separation, being relatively undemonstrated for waste treatment, may not be appropriate for removal or treatment of the contamination in the ground water at Firestone Salinas. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.1.16 Evaporation/Crystallization/Drying

Evaporation, crystallization, and drying operations will each be considered in this section. These operations involve the controlled application of heat to drive off volatile materials. For the purposes of this discussion, evaporation, crystallization, and drying do not involve chemical reaction (other than phase changes) or thermal degradation of the materials involved. Thermal degradation processes for waste materials are discussed in Section 2.4.4 under "Thermal Treatment." Evaporation, crystallization, and drying are similar operations except for the extent to which the heating is carried out. Evaporation, crystallization, and drying are equilibrium processes operating based on mass-transfer principles and the different volatilities of chemical species.

Evaporation is applying heat for the purpose of concentrating liquids that may be pure, solutions, suspensions, or emulsions. Evaporation may also be used to remove a particular volatile component in a liquid (Wiegard, 1978). The applications and variations of evaporator design are quite numerous, and will not be discussed in detail. Evaporation is used in many chemical processing operations, for solvent recovery, food processing, and water purification (from brine). Evaporation may be induced by direct or indirect heating or by the sun (solar evaporation which is usually carried out in outdoor shallow ponds with large surface areas).

Crystallization is an evaporation-type process; however, the goal is to recover dissolved solids instead of a concentrated liquid. By continuing to apply heat, evaporating the solvent until the saturation point of the solvent is reached, precipitation of dissolved solids will occur. Careful control of this process yields crystals of the dissolved product, which can be recovered. These crystals may be dry or slightly wet, or even slurried, depending on the design of the crystallization process.

Drying is a process which produces solvent-free crystals from either a saturated solution or a feed stream of moist or slurried crystals. Dryers apply sufficient heat to drive off all free solvent.

For brevity, the discussion of the many designs for evaporators, crystallizers, and driers will be omitted. Further information is given in the 6th edition of Chemical Engineers Handbook.

Evaporation, crystallization, and drying are suitable processes for treating, concentrating, or removing a wide variety of contaminants in waste streams. These include heavy metals, radioactive materials, inorganic salts, and many types of organics (including halogenated organics). The wastes may be aqueous, nonaqueous, liquid, slurries, sludges, tars, or solids (Berkowitz et al., 1978, pp. 466-467). The economics are usually limited by energy consumption.

Evaporation, crystallization, and drying would not be cost-effective methods for removal of the low levels of organic contamination in the Firestone Salinas ground water due to high energy consumption. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2 Chemical Treatment Methods

2.4.2.1 Neutralization

This treatment method is generally applied to the treatment of acidic or basic solutions of gases, salts, buffers, or organics. The method uses controlled addition of an acid or base to a solution to either raise or lower pH to meet a particular requirement (e.g., permit limit), or to achieve the formation of a precipitate such as an oxide or hydroxide (see precipitation). Gases such as sulfur dioxide, carbon dioxide, or ammonia can be used as sources of acids or bases (once in solution). Also solids such as lime, sodium hydroxide, or sodium bisulfite are a convenient form of neutralizing agent. Organic acids or bases may be used but are not usually economical on an industrial scale. This treatment method is most appropriate for acid waste or basic waste in the pH range of 0 to 14 and for removal of certain metal ions (see precipitation). Treatment of highly concentrated acids or bases (outside the 0 to 14 pH range) can be acccomplished by neutralization, but requires large amounts of chemical agents and a means to remove the excess heat generated. Neutralization (pH adjustment) will also aid in the separation of some concentrated oil-water mixtures (at or near saturation) and breaking of emulsions (see oil-water separation). Control of chemical addition is essential to prevent the generation of undesirable species (such as nitrogen trichloride) and overshooting a neutralization point. Possible chemical side reactions have to be reviewed before implementing a neutralization process to avoid producing undesirable side products. Approximately 15 to 20 minutes residence time is necessary for neutralization reactions to reach complete equilibrium. This often makes precise control of addition rates difficult, especially when adjusting near neutral pH.

Neutralization would not be effective in the treatment or removal of low concentrations of dissolved synthetic chlorinated organics as found in the Firestone Salinas ground water. However, neutralization is used at the Firestone Salinas site to adjust the pH of the treatment plant effluent to comply with the NPDES discharge requirements.

2.4.2.2 Precipitation

The two types of precipitation discussed in this section are liquid-solid precipitation, and electrostatic precipitation. Each of these is discussed in the following subsections.

Liquid-Solid Precipitation

This technology removes a contaminant by creating a second phase that can then be removed or recovered. Several methods can be used to induce precipitation in a solution. Addition of a chemical that will react with a species in solution to form an insoluble product is an effective way to force precipitation to occur. Materials such as hydrogen sulfide or sodium sulfide, when added to solutions containing heavy metals, will cause precipitates in the form of insoluble metal sulfides to drop out of the solution. The solubility of most metal sulfides (in water) is extremely low. Precipitating heavy metals and removing the precipitate by media filtration methods reduce the environmental toxicity of the remaining solution. Chemical addition may also be used to cause a shift in the equilibrium, resulting in precipitation or coalescence. This often occurs as a result of simple pH adjustment.

Temperature change is also used to achieve precipitation. Cooling a solution lowers the solubility of a dissolved species, ultimately to the point of saturation and precipitation. Heating a solvent containing dissolved components will result in evaporation of the solvent. (Refer to Section 2.4.1.16 Evaporation/Crystallization/Drying.) Once the saturation point is reached in the remaining solvent, precipitation of the solute will occur. This technology is best suited for high concentrations in solution and more particularly for inorganic species and metal ions.

Precipitation would not be effective for treatment or removal of dissolved organics found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Electrostatic Precipitation

This treatment method is an electrolytic treatment method for removal of particulates from gas streams. Gas from a combustion or chemical process is passed between two plates energized with ac electric current. Particulates through the field become charged and migrate to one plate or the other depending on the charge of the particle (electrical attraction). The plates eventually become loaded; and periodically the current is shut off, and the plates are cleaned by mechanical means, such as compressed air blasting. This treatment method is used commercially for cleanup of stack gases from power plants.

This method would be ineffective for treatment of the Firestone Salinas ground water. Thus, no further consideration will be given to this method for implementation at the Firestone Salinas site.

2.4.2.3 Ion Exchange

Ion exchange treatment technology uses natural or synthetic inorganic crystals (zeolites), stationary-phase synthetic ion exchange resins, or dispersed chelating agents to remove or bind ions contained in a solution. Ion exchange is generally limited to removal of metal ions or charged organic species such as cyanide. Stationary-phase synthetic ion exchange resins consist of a polymeric backbone with various active salt-forming organic groups attached to the end of the polymer chains. Potential active groups may be sulfonic, carboxylic, phenolic, and various amine groups. The ion exchange process is a reversible exchange between the insoluble solid salt (the ion exchanger) and an ion-containing solution. The driving force for the exchange of ions between the exchange agent and solution is a function of the equilibrium determined by the relative insolubilities of the salts that can form by ions present and the exchange agent. Adjusting concentrations or shifting the pH changes the relative solubilities, thus making the process reversible. Reversibility allows for recovering the species removed from the solution and essentially endless regeneration/reuse of the resin (Berkowitz et al., 1978, pp. 633-636).

Chelating agents are structurally similar to synthetic ion exchange resins except that the polymer backbone, which makes resins fixed phase, is not present. The active agent is free to move throughout a solution. Chelants are used most frequently to bind metal ions in solution, usually to prevent them from interfering with polymerization or other chemical reactions. Stationary-phase resins are usually best suited for waste treatment applications because the contaminants are actually removed, not just bound in an unavailable form.

In actual operation, the ion exchange resin in the form of polymeric beads is loaded into a column. The solution to be treated is usually passed downward (concurrent) through the resin column. Ions from the resin are exchanged for ions in solution. Either cations and anions can be exchanged, depending on the resin type. Various resin forms are available such as sodium-ion exchange resins or hydrogen-ion exchange resins. These resins (sodium and hydrogen) can be regenerated with strong salt solutions or acid solutions respectively, when exhausted (a reversal of the equilibrium). There are also various column configurations that allow for cocurrent, countercurrent, or continuous operation.

Ion exchange technology is best suited for removal of ionic species. Ion exchange would be ineffective for removal or treatment of the dissolved organics found in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2.4 Oxidation

The six oxidation technologies that have potential in waste treatment applications are as follows:

- Chemical oxidation
- Wet air oxidation
- Supercritical fluid oxidation
- Electrolytic oxidation
- Thermal oxidation
- Biological oxidation.

The first three of these technologies are each discussed in the following subsections. The last three technologies, electrolytic oxidation, thermal oxidation, and biological oxidation, are discussed in Section 2.4.2.5 - Reduction, Section 2.4.4 - Thermal Treatment, and Section 2.4.3 - Biological Treatment.

Chemical Oxidation

Chemical oxidation treatment is the controlled addition of chemical oxidizing agents to a waste stream to cause chemical transformation (via oxidation) of the waste to simpler or less toxic components. Sources of oxidants include air, oxygen, ozone, hydrogen peroxide, chlorine, chlorates, chlorites, hypochlorites, perchlorates, permanganates, or strong oxidizing acids (such as nitric acid). The ideal products of chemical oxidation reactions are simple nonhazardous components such as carbon dioxide or water. Often species such as HCl, NO_2, or SO_3 are generated that may require additional treatment before ultimate disposal. These reactions are termed "redox reactions" since oxidation (of the water) and reduction (of the oxidizing agent) occur at the same time.

Oxidation of some species may also produce insoluble precipitates. This occurs when solutions of metal ions are oxidized to produce metallic oxides or hydroxides. Precipitates may then be removed by media filtration or centrifugation, leaving a less environmentally toxic solution. The effectiveness of the oxidation process depends on the chemistry and reactions involved. The usual limitations are removal of evolved heat (oxidations are generally exothermic), control of side reactions that may generate unwanted intermediates (and consume the active oxidant), reactivity of the waste species, and toxicity of the oxidation products. Chemical oxidation is a method primarily for treatment of organic-containing wastes of moderate to high reactivity. Moderate to high reactivity organics include alcohols, ketones, organic acids, alkyl and nitro-substituted aromatics, unsaturated alkyl groups, carbohydrates, phenols, aldehydes, amines, and various sulfur compounds. The selection of an oxidant is made based on a number of factors including cost, availability, side reactions, oxidant strength, and toxicity.

Low reactivity compounds include halogenated hydrocarbons, saturated alphatics, and benzene. These types of compounds are particularly resistant to chemical oxidation. Chemical oxidation of these low reactivity organics may be difficult, expensive, slow, or impossible to accomplish only by chemical means. Chemical oxidation in conjunction with UV light (photolysis) is effective for some of these species (see photolysis - Section 2.4.2.6). Further, some organics such as polyethylene or polypropylene have very low reactivity toward chemical oxidants and are classified as refractory organics. These materials can be oxidized only by using other methods such as thermal oxidation.

Chemical oxidation would be effective in treating the dissolved chlorinated organics in the Firestone Salinas ground water. However, the probable slow reactivity of these organics with chemical oxidants would require longer retention times and large holding volumes to achieve complete destruction. Ultraviolet (UV) radiation treatment with chemical oxidants has been demonstrated as effective; however, the capital cost, potential adverse side reactions (which may produce HCl or short-chain chlorinated organics), and byproducts of this type of treatment make it potentially unsuitable. Thus, no further consideration will be given to this treatment technology for implementation at the Firestone Salinas site.

Wet-Air Oxidation

Wet-air oxidation is a process technology that uses oxygen (usually using air as the source) and water under high temperature and pressure (but under the critical point of water) to oxidize organics and certain metal ions. The technology is primarily applicable for treatment and detoxification of municipal sludges and moderate concentrations of most organics.

The process begins by preheating the feed and pumping it into the wet-air oxidation tower (reactor). The pressure and temperature required for destruction is specific for each waste type depending on how resistant the waste is to oxidation and the BOD/COD requirement. Essentially a wet-air oxidation reactor is a BOD/COD reducer. The primary limitations on capacity are the residence time, blower capacity (oxygen source), heat transfer, and organic concentration in the waste stream.

The organic concentration and composition of feed wastes is the primary economic factor influencing the applicability of this method. Although wet-air oxidation can be used to treat most organic waste streams, dilute or highly concentrated wastes are more costly to treat. The process requires heat, usually derived from the reacting feed, to maintain temperature and pressure. Low concentrations of organics in the feed do not provide enough heat value to self sustain the process. Dilute waste streams require additional fuel, usually added to the feed in the form of diesel fuel or kerosene. High concentrations of organics in the feed produce excess heat, requiring high water consumption to remove the excess heat from the reactor (in the form of steam) and making control more difficult. Economic operation and control depend on a consistent feed concentration.

In actual operation of a wet-air oxidation reactor, water and waste (and fuel if necessary) are premixed and balanced, then fed to the reactor to maintain near-constant temperature and pressure. Water must be present to provide steam for pressure and a media for the (wet phase) oxidation reaction to take place. A consistent feed is essential to prevent drastic pressure and temperature shifts and possible incomplete treatment. Catalysts such as nitric acid are sometimes used to speed up the reaction or allow operation at lower temperatures. Wet-air oxidation is particularly effective to treat refractory organics such as polyethylene, chlorinated organics, pesticides, and other otherwise untreatable wastes. Treatment of halogenated species and other types of organics may produce aggressive by-products that require exotic metallurgy. Reactors are usually constructed of high-grade stainless, nickel alloys, or titanium.

Wet-air oxidation has only been pilot demonstrated (10 gpm) for hazardous waste treatment (Zimpro, Series 300). This technology requires sophisticated process control and peripheral equipment such as high-pressure pumps and compressors, and exotic alloy heat exchangers. Some of the other problems associated with operation of a wet-air oxidation reactor include disposal of salts in the treated effluent and control of fugitive emissions. The technology is very well suited for the treatment of municipal sludge. Numerous full-scale wet-air oxidation installations are in operation at POTWs throughout the country.

Wet-air oxidation technology is not considered economical for dilute wastes due to potential high energy cost and consumption. Wet-air oxidation would not be economical for treating the low concentrations of chlorinated organics in the Firestone Salinas ground water. Also, the capital cost to meet the capacity (ground water volume) requirement would make this technology prohibitively expensive to implement. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Supercritical Fluid Oxidation

This technology is similar to wet-air oxidation except that the operating conditions are above the critical temperature of water. Under these conditions of high temperature and pressure, salts precipitate and can be recovered. Organics are completely oxidized or can be extracted and recovered depending on the supercritical fluid medium (i.e. water, carbon dioxide, etc.). This process is being discussed as an oxidation technology since recovery of toxic organics in waste treatment is usually less important than destruction, especially for dilute solutions. In waste treatment, the primary application of the technology is to oxidize organics to the simplest constituents and recover metal salts (usually in the form of oxides). Often this technology is referenced in the literature as supercritical fluid extraction. The technology may fit in either category depending on the operating conditions. In this section, the technology is considered as a high-pressure supercritical variation on wet-air oxidation treatment.

Control and metallurgy problems are magnified in supercritical fluid oxidation processing because of higher operating temperatures and pressures and the more aggressive operating environment. Pumps, heat exchangers, and other peripheral equipment must be constructed of exotic materials. Equipment becomes expensive to meet the demand of rigorous operating conditions. However, one advantage of supercritical operation is that the reactor volume and required residence time in the reactor to achieve complete oxidation are much smaller (than for wet-air oxidation). This results in downsizing of much of the equipment. Despite this advantage, however, the technology does not have any commercial demonstrations reported to date for waste or hazardous waste treatment. Extensive laboratory work and testing have been performed, resulting in the issue of several patents for the use of supercritical fluid oxidation in hazardous waste treatment. Other applications of supercritical fluid technology have been commercialized, including a supercritical fluid extraction process to remove caffeine from coffee.

Supercritical fluid oxidation technology has not been commercially demonstrated or piloted. Supercritical fluid oxidation has not been proven as a suitable method for the treatment of ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2.5 Reduction

Reduction technology for chemical separation or transformation is well known in the production of pure reactive metals, in refinery processes, and waste treatment. The following three types of reduction processes are discussed in this section:

- Electrolytic oxidation/reduction
- Chemical reduction
- Direct hydrogenation.

Each of these methods is discussed individually in the following subsections.

Electrolytic Oxidation/Reduction

Electrolytic reduction involves application of dc electric current across an electrolytic cell. Control of voltage and amperage can affect many separations that are impossible using other methods. Electrolysis of molten salts is a technique used to produce materials, such as sodium metal, aluminum, magnesium, fluorine, and other very reactive materials. Electrolysis of salt solutions is the major process for producing chemicals such as sodium hydroxide and chlorine. In an electrolytic cell, oxidation and reduction take place simultaneously at the anode and cathode respectively. Reduction reactions often produce pure metals or hydrogen (from reduction of hydrogen ions present in solution or reduction of water). Reactive metals when electrolyzed from solutions further react with the solution to form other species. This occurs when sodium chloride solutions are electrolyzed. The final products are chlorine, hydrogen, and sodium hydroxide. The intermediate product of sodium metal is electrolyzed from the solution but immediately reacts with the water present to form sodium hydroxide and hydrogen. Electrolytic cells have been developed and improved for various waste treatment applications. The primary use of this technology is for treatment of waste streams containing dissolved metals or ionized organics.

Over 200 commercial electrolytic treatment systems are in use for heavy metal treatment. This technology has been extended to treatment of ground water containing heavy metal contamination. Variations on the electrochemical cell have proven effective for the treatment of fluorides and non-ionized organics. The electrolytic process is effective for treatment of such a wide variety of waste because it provides four treatment operations in one unit. Oxidation and reduction occur at the anode and cathode. Electrolysis of water produces hydroxide, which helps adjust the pH and precipitate metals. A sacrificial iron anode is oxidized to produce iron hydroxide in solution. This form of iron (as reported in Section 2.4.1.5, under Physical Adsorption), acts as an adsorbent. In solution both ionized and non-ionized species (organics) may be trapped in the iron hydroxide matrix and coprecipitated. Further evaluation of this treatment method is ongoing for treatment of organics. Ground-water treatment where both inorganic and organic contamination are involved might be easily and more economically treated with a single electrochemical unit as compared to other multiple treatment operations addressing each waste type (Berkowitz et al., 1978).

Electrochemical treatment is an emerging and relatively untested technology for removal of chlorinated organic hydrocarbons. The technology may not be totally effective for treatment of the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Chemical Reduction

Chemical reduction uses chemically induced reduction reactions to cause a net reduction in the oxidation state of a chemical species. Waste treatment is performed by selecting reducing agents that are powerful enough to convert (reduce) a hazardous species to less hazardous or nontoxic species of a lower oxidation state. A good example of this technology applied to waste treatment is the reduction of Chrome VI to Chrome III using sodium sulfite, bisulfite, metabisulfite, or sulfur dioxide as the source of the reducing agent. The reaction proceeds under acidic conditions by converting the sulfite source to free sulfurous acid. The sulfurous acid is oxidized by the Chrome VI to sulfate. Chrome VI is alternatively reduced to Chrome III. The chemistry is fairly complex, as is the case for most chemical reduction reactions. These reactions are termed Redox reactions since oxidation and reduction occur at the same time.

Chemical reduction of metals dissolved in solution is a common waste treatment operation. Reduction technology also extends to the treatment of organics but is limited. Reagents such as borohydride, lithium aluminum hydride, aluminum hydride, reactive metals such as sodium, potassium, or lithium, hydrazine, diborane, and a host of other agents can be used to reduce organics. The reactivity of these reagents limits their usefulness in waste treatment since many are also very water reactive. Reducing agents are often added to chemical manufacturing processes to scavenge for impurities.

Chemical reduction technology is primarily effective for treating wastes containing metals. The limited applications of this treatment technology for organics makes this method impractical to treat the low-level concentrations of synthetic organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Direct Hydrogenation

Under pressure and usually with the aid of a catalyst, many organic species can be directly hydrogenated and subsequently reduced. The technology involves direct addition of hydrogen to a wide variety of organic functional groups. The conditions required may be mild, as is the case with aromatic amines and aromatic nitro compounds (that can be hydrogenated at 3 to 4 atmospheres using a nickel catalyst). Benzene can be hydrogenated to cyclohexane but requires hydrogen at several hundred atmospheres and high temperature (House, 1972). Direct hydrogenation requires careful process control and safety measures for handling the hydrogen gas. The technology has wide application in synthetic organic and petrochemical manufacture but limited application to waste treatment due to the safety concerns, capital costs, and rigorous operating conditions.

Direct hydrogenation would be unsuitable as a treatment technology for the low levels of synthetic organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2.6 Photolysis

Photolysis, as applied to waste treatment, is the inducement of chemical transformations using light. Light, for the purposes of this section, refers to radiation within the ultraviolet (UV), visible, or infrared (IR) radiation spectrum. Other frequency ranges are discussed in Section 2.4.2.7 under Irradiation. Breaking of bonds using light is well known in organic chemistry. Light of the appropriate frequency and intensity cleaves many types of chemical bonds, according to the principles of quantum mechanics. The mechanisms are complex and the applications specific, but the technology has usefulness, especially in the treatment of difficult-to-handle compounds such as pesticides and dioxin. Light sources may be the sun; low, medium, or high pressure mercury-arc lamps; fluorescent lamps; or lasers. The selection of the light source depends on the required intensity and frequency of the radiation necessary to accomplish the desired chemical transformation. Photolysis is often applied in conjunction with other technologies such as UV and ozone treatment, UV and chlorine treatment, or UV and peroxide treatment. The major advantage of this technology is that specific bonds can be targeted by selection of the appropriate frequency and intensity of the light source.

UV light is frequently used as a sterilizing agent. A number of commercial applications have been developed as well as demonstrated in pilot plants for treatment of dioxins and PCBs. Rearrangement, side reactions, and the by-products produced may limit the application of this technology. The treatment may produce species which are as hazardous or difficult to remove as the original contaminants. The residence time required to achieve complete destruction may limit processing capacity or require a prohibitive increase in the size of the photolysis reactor. Also, depending on the light intensity required, energy consumption could be extremely high.

Technical limitations would make photolysis impractical for treatment of the dissolved organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2.7 Irradiation

Irradiation using high-energy gamma rays, x-rays, or microwaves is currently an experimental method for hazardous waste treatment. Microwave irradiation of metal-containing organics with oxygen in the plasma phase is an experimental method to remove metals by depositing the metals in the form of metal oxide films. This technique would have limited commercial value in waste treatment due to cost; however, it might be developed for production of high technology ultrapure materials.

Gamma irradiation treatment is an experimental method that has been applied to the treatment of pesticides. Gamma irradiation of labile food stuffs is a highly controversial method for sterilizing, preserving, or prolonging shelf life.

Irradiation treatment using sources such as radio waves would not be effective in waste treatment applications. Radio-wave frequencies and bandwidths have the wrong magnitude or are the wrong frequency to break chemical bonds or cause chemical transformations.

The drawbacks of irradiation use in waste treatment are limited applicability, safety, and energy consumption. High-energy gamma ray sources, x-ray sources, and high-energy microwave generators require extensive shielding and isolation to protect operating personnel. Gamma ray sources are often expensive and require careful handling and licensing as a nuclear material. X-ray and microwave generators become expensive as they become larger for commercial applications. Also, energy (electrical) consumption becomes a cost factor with larger commercial x-ray and microwave units.

Irradiation is currently an experimental method for treatment of very difficult-to-treat or extremely hazardous wastes. Sterilization by irradiation is a potential commercial application but has drawbacks.

The limited demonstrated waste treatment applications and safety concerns make this method inappropriate for removal or treatment of the dissolved organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.2.8 Stabilization

Stabilization is a treatment process for immobilizing waste materials to prevent them from entering the environment or food chain. Stabilization does not destroy the waste but alters it chemically or physically to prevent mobilization (leaching). Other terms that describe this process are fixation, encapsulation, or cementation (Parmele et al., 1986)

The four stabilization processes are as follows:

- Inorganic microencapsulation/fixation (incorporate the waste into a silicate-based mix such as cement or kiln dust).
- Inorganic vitrification (melt or fuse the waste, discussed in Section 2.4.4 under thermal treatment).
- Organic microencapsulation (incorporate the waste into a polymer or asphalt matrix).
- Organic encapsulation (surround a waste volume in a polymer shell).

These will be discussed separately as inorganic and organic stabilization methods.

Inorganic Stabilization

Inorganic stabilization may involve the following chemical reactions:

- Neutralization (acid/base)
- Precipitation (insolubilization)
- Hydration
- Addition
- Substitution
- Complexation
- Ion Exchange
- Adsorption.

The process involves the interaction between the waste (soluble) and silicates, alkali, water, salts, and the ions present. The result is the microencapsulation of insoluble waste particles and solidification of the liquid waste fraction. The reactions are termed cementation reactions or pozzolanic reactions. The difference between cement and pozzolanic materials is that pozzolanic compounds require lime to form a cement (materials such as fly ash or volcanic ash), whereas materials like calcium silicate do not. Waste materials, cement material, water, and stabilizers are balanced and mixed in a pug mill or other solids blending unit. Once the cementation reaction takes place, the waste material is encapsulated and should not be leachable.

Stabilization is a useful method for treatment of metal-containing wastes. Metal-containing waste must be either recycled or stabilized since they are not destroyed by conventional treatment methods. The cementation reaction does take some time to go to completion. The reaction also requires water. Totally dry solids must be wetted in order to stabilize them. Likewise, extremely wet or diluted materials become extremely expensive to treat due to the large amount of cement material required to form the mix. Some materials such as acids may require neutralization or pretreatment to prevent interference with the cementation reaction.

Inorganic stabilization would be uneconomical for treatment of the low-level organic contamination in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Organic Stabilization

Organic stabilization uses polymers, asphalt, polyolefins, or plastics to encapsulate or isolate (microencapsulate) waste materials. Encapsulation is the sealing of a large waste mass with the stabilization agent (i.e. a vault around the waste mass). Microencapsulation involves the blending of the stabilizing agent through the waste, forming an aggregate that hardens, isolating individual waste particles from each other and from the environment. This process usually requires heating or in situ catalysis of a monomer (resulting in formation of the polymer). When the encapsulating material cools, it hardens into a stable refractory organic, inert to all but the most aggressive attack. This method is more expensive than inorganic treatment and would not be appropriate for dilute aqueous wastes.

Organic stabilization would not be an appropriate or cost-effective treatment method for the dissolved organic contamination in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3 Biological Treatment

The following seven biological waste treatment methods will be discussed:

- Aerobic degradation
- Anaerobic digestion
- Enzymatic conversion
- In situ biological remediation
- Controlled bacterial applications
- Composting
- Aquaculture.

Variations on each technology will be discussed where appropriate within the individual sections.

2.4.3.1 Aerobic Degradation

Aerobic degradation is a biological treatment process that uses natural bacteria to convert (oxidize or hydrolyze) waste organics by enzymatic action. Aerobic degradation requires oxygen by definition and function. The following aerobic processes are the most commonly used in waste treatment today (Other less common methods function by similar biological mechanisms and will not be discussed individually for the purpose of brevity):

- Activated sludge treatment
- Aerated ponds or lagoons
- Trickling filters
- PACT™ (powdered activated carbon treatment).

These are discussed individually. PACT™ (a registered trademark of Zimpro Inc.) is discussed separately in Section 2.4.1.5.

Activated Sludge Treatment

Activated sludge treatment is a biological process that relies on the generation, maintenance, and continuous recycling of biomass (living bacterial culture) to decompose organic matter. The biological decomposition of the waste is the result of enzymatic conversion of organic matter as part of the life functions of the bacteria.

Activated sludge treatment is applicable to waste streams containing less than 1 percent solids and moderate concentrations of organics. Very low organic concentrations do not provide enough "food" to sustain the activated sludge biomass. Very high concentrations may require additional dissolved oxygen added as air or pure oxygen under pressure. Activated sludge processes are sensitive to heavy metal contaminants. Although the biomass can be acclimated to tolerate metals, it is best to pretreat the influent with lime to remove them. The biomass acts as a BOD/COD reducer, able to digest a wide variety of organic contaminants. However, not all species are degraded, such as certain refractory organics and species including polychlorinated biphenyls. Some halogenated organics can be degraded but at slower rates compared to other organics. Activated sludge processes are very sensitive to drastic changes in feed concentration. The biomass must be acclimated slowly; otherwise, the bacterial culture may die.

The activated sludge process requires two steps. In the first step, the incoming waste feed is mixed with recycled biomass (from the clarifier), aerated, and allowed to react in the aeration basin. In the second step, the mix flows to a clarifier, where the activated sludge is allowed to settle. A portion of the sludge is recycled to the aeration tank and a portion is sent for disposal. The effluent (overflow) from the clarifier decants and is sent for further treatment or disposal. Pretreatment of the feed may be necessary to remove metals or adjust the pH. Often a large equalization tank is used to stabilize possible shifts in waste feed composition. Nutrients may also be added to enhance and optimize bacterial growth and function.

Activated sludge treatment would not be cost effective to treat the low levels of contamination in the Firestone Salinas ground water. There are not enough organics in the ground water to sustain an activated sludge biomass. Also, the retention times required would make implementation of this technology prohibitively expensive due to massive holding basins and clarifiers. Thus, no further consideration will be given to this technology for implementation at the Firestone Salinas site.

Aeration Ponds or Lagoons

A common and effective aerobic treatment method is an aeration pond or lagoon. Aerobic bacterial action is most effectively used for treatment of dissolved organic species. A relatively shallow pond when mechanically aerated becomes an efficient aerobic waste treatment reactor. Although an aerated pond is not as efficient as an activated sludge process, net treatment cost is cheaper due to lower initial materials and construction cost (assuming land is relatively inexpensive and available.) Aeration ponds are best suited for treating waste streams with loadings of less than 1 percent solids. Higher solids loading may fill up the pond quickly, requiring expensive dredging to restore operation. Aeration ponds require longer retention times than activated sludge treatment. Depending on the pond depth, both aerobic and anaerobic activity may take place. Aeration ponds are sensitive to changes in ambient temperature. Biological activity drops off below 30°C and may cease near freezing.

Aeration ponds may not be totally effective for treatment of the dissolved chlorinated organics in the Firestone Salinas ground water. Also, the slow rate at which aerobic bacteria breakdown chlorinated organic hydrocarbons would require a very large pond to provide adequate residence time. The cost of construction and procurement of land make this method unsuitable. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Trickling Filters

A trickling filter is a simple application of aerobic biological treatment. A packed bed of stones or synthetic media provides a surface for a bacterial slime to grow and develop. As the waste flows through the filter bed, contaminants are removed and digested by the bacterial cell mass (slime). The advantage of a trickling filter is that it provides a large surface area for the bacterial slime to grow, a large area for intimate contact of the waste stream with the bacterial mass, and a means to aerate the waste stream, providing good conditions for biological activity. Anaerobic bacteria may also grow underneath the aerobic bacterial slime, if the slime layer grows thick enough. Thus, both anaerobic and aerobic reactions may occur within the same unit. Trickling filters decompose a wide range of organics similar to an activated sludge process. However, since the residence time within the trickling filter is less than for an activated sludge treatment unit, the efficiency is not as high. Reflux of a portion of the filter effluent is one technique that helps improve efficiency. Trickling filters have the advantage over activated sludge treatment of being more tolerant of shock loading. Also, trickling filters tend to produce a more uniform effluent quality when influent quality varies. Shock loading should be avoided as much as possible as it may cause overgrowth of the bacterial and sloughing of the bacterial slime mass from the filter packing. Shock loading as a rule should be avoided with all biological treatment processes (Berkowitz et al., 1978, pp. 253-259).

A trickling biological filter would be inefficient for treatment of the low concentration of organics in the Firestone Salinas ground water. There would not be an adequate amount of organics present to sustain sufficient bacterial mass. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.2 Anaerobic Digestion

Anaerobic digestion is a bacterial treatment process that takes place in the absence of air (oxygen). Two types of bacteria work in conjunction (symbiosis) with each other. Acid-forming bacteria hydrolyze complex organics to organic acids, alcohols, carbon dioxide, and hydrogen. Methane-producing bacteria utilize the end products of the acid-forming bacteria to produce methane and cell mass. The process produces a low amount of waste sludge because a high portion of the organics are converted to methane and CO_2 instead of cell mass. The process can tolerate a higher percentage of solids, up to 15 percent. Conventional digesters are closed tanks with no agitation and provide a retention time of 30 to 60 days. High rate digesters have provisions for mixing, reducing the retention time to an average of 14 to 16 days. Sludge volume can be reduced 40 to 60 percent by anaerobic digestion compared to aerobic digestion (Berkowitz et al., 1978, p. 218).

Control of an anaerobic treatment process is essential. Anaerobic bacteria reproduce slowly, thus controlling upsets is critical to performance. Upsets occur when acid-forming bacteria increase in number relative to their methane-forming counterparts. This produces an excess of acid, reducing the number of methane-forming bacteria. Methane-forming bacteria are sensitive to acid build up. Should an acid imbalance occur, pH adjustment or shut down of the feed may be necessary to prevent totally killing all the methane-producing bacteria. This would result in digester failure that is very odorous and messy to clean out. Anaerobic bacteria are also sensitive to certain metals and various organics depending on the concentration. The technology is most appropriate for waste streams containing volatile solids and a good supply of digestible organics (Berkowitz et al., 1978).

Anaerobic digestion would not be suitable for treating the low levels of synthetic organics in the Firestone Salinas ground water. Inadequate organic feed to sustain bacterial and long residence time requirements would eliminate this method on the basis of operating and capital cost. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.3 Enzymatic Conversion

Enzymes are natural biochemical catalysts manufactured by living cells that allow specific life function chemical reactions to occur under mild temperate conditions (around 30°C). Enzymes typically are polypeptide chains (amino acids) of molecular weights in the range of 1×10^6 mass units (Mark, 1985).

There are four categories of enzyme activity. Absolute enzymes catalyze only one specific reaction. Stereospecific enzymes catalyze reactions of one type of optical isomer but not the other, but may also cause reactions in a similar class of the same optical configuration. Hydrolyzing enzymes react with a specific organic group, such as alcohols, esters, or organic acids. Point-specific enzymes react at specific sites on a particular molecule, such as cleaving of a specific bond (Mark, 1985).

The structure and order of amino acids making up the enzyme determine its reactivity and function. The primary enzyme structure is determined by the linear configuration or order of the amino acid units. Further structure results as the chain twists and folds on itself, giving it a highly intricate, three-dimensional structure and spacial arrangement. The intricate enzyme structure results in the creation of very specific sites on the enzyme molecule. These catalytic sites allow very specific reactions to occur (Morrison et al., 1973). Enzymes are temperature sensitive, being deactivated at 50° to 70°C. This is a result of higher temperatures distorting the enzyme structure. Weak hydrogen bonds may be stretched or broken at higher temperatures, disorienting or destroying the specific catalytic site on the enzyme molecule.

Enzymes are produced as part of the continuing life function of cells, governed by instructions in the cell's DNA. Specific enzymes may be recovered from various sources including plants, animal organs, and cell cultures (Mark, 1985).

Enzymes simply added to solution may lose their catalytic activity rapidly due to agitation, pH, metals in the solution, temperature, and other organics present. Various methods have been developed to immobilize enzymes on fixed substrates. Immobilization allows use of the enzyme similar to catalysts packed in a fixed bed reactor. Fixed or soluble enzymes may be introduced into a stirred tank reactor, accelerating a desired conversion. Enzymes might then be recovered for reuse or removed if catalytic activity is lost. Commercial applications of enzyme conversion include the production of high fructose corn syrup, production of antibiotics, and fermentation.

Waste treatment is generally performed using the bacteria, which produces the enzyme rather than recovering a specific enzyme and using that to break down a particular toxic component. There are enzymes that perform conversions, such as converting urea to carbon dioxide. The literature surveyed did not report specific enzymes for treatment of chlorinated organic hydrocarbons. However, various types of aerobic bacteria are known to break down chlorinated organics slowly. Few examples of the isolation and commercial availability of specific enzymes that might be used in ground water treatment are reported in the literature.

Enzymatic conversion is inappropriate for treatment of the Firestone Salinas ground water due to the unavailability of suitable enzymes. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.4 In Situ Biological Remediation

This technology is a method used to enhance the natural breakdown of contaminants that have been released into ground water or soil. The technology involves injecting nutrients and available oxygen-enhancing chemicals (such as hydrogen peroxide) into an underground contaminated aquifer. Nutrients and increased oxygen levels stimulate natural bacterial growth. The increased numbers of bacteria break down the contaminants present at an accelerated rate as a result of the artificially enhanced optimized growth conditions. In addition, the bacterial action accelerates the release of contaminants adsorbed on soil particles. When the remediation is completed, bacterial levels return to normal, leaving no hazardous residuals. In situ biological remediation, when technically appropriate to implement, may cut the remediation time for a site by 90 percent over pump-and-treat methods alone. In situ biological remediation works best when dissolved organic concentrations are high. Usually pump-and-treat methods are combined with in situ biological remediation to control the flow of nutrients. Nutrient solutions can be directed within a contamination plume by injecting upgradient of a pump-and-treat extraction well. In situ biological treatment can be effective for vadose zone contamination, provided a suitable delivery method (such as percolation) can be devised to deliver nutrient solutions.

Cultured natural bacteria (selected to consume specific contaminants) may also be injected in addition to the nutrient solutions. Release of certain genetically engineered bacteria into the environment is still controversial but may have some application in the future. Genetic engineering may allow the development of bacteria that will treat difficult or slow degrading contaminants such as DDT or PCBs. Chlorinated hydrocarbons pose a particular problem as they are slow to degrade biologically.

In situ biological remediation would be difficult to implement at the Firestone Salinas site due to the size and depth of the plume, high recharge rate of the aquifer, and low concentrations of organic compoundss in the ground water. The benefits are limited due to slow biological breakdown of chlorinated organics. The additional cost is not considered to be justified. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.5 Controlled Bacterial Applications

Engineered bacterial applications fall into the following two categories:

- Naturally selected
- Genetically engineered.

Each of these applications is discussed in the following subsections.

Naturally Selected Bacteria

Since early civilization, bacteria and yeast have been used to produce wine and cheese through fermentation. As more was learned about these processes, the specific natural bacteria that cause these transformations were isolated. Recent progress has allowed culturing, drying, and preserving a wide variety of natural bacterial strains to perform many chemical synthesis and waste treatment operations.

Dried bacterial cultures are available to decompose oil, gasoline, grease, and various organics. Normal mutation that occurs in the bacterial population has led to isolating and culturing tolerant mutant strains of bacteria that will break down normally difficult to treat or slow degrading wastes such as pesticides, chlorinated organics, phenols, and dioxins.

Addition of selected bacteria to treatment units (such as activated sludge systems or anaerobic digesters) in sanitary plants greatly improves the efficiency and ability of these plants to handle industrial-type wastes and remain within permit limits.

Selected bacteria have potential applicability for in situ treatment of materials released to the environment. The cleanup of oil spills on coastal areas is dramatically enhanced by application of oil-digesting bacteria. In situ biological remediation combined with pump-and-treat methods can also be enhanced by the addition of selected bacterial strains specific to the selected waste type (PolyBac Corporation, 1989). The limitations on using naturally selected bacteria are those imposed by the methods of application (i.e., trickling filter, in situ treatment, activated sludge, etc.).

Naturally selected bacteria would have limited effectiveness in treatment of the low concentrations of chlorinated organics in the Firestone Salinas ground water. As stated in other sections, bacteria are slow in degrading chlorinated organics. Furthermore, the aquifers at the Firestone Salinas site are not ideally suited for in situ biological treatment due to high recharge rates. It would not be economical to consider surface biotreatment of pumped ground water due to residence time and large holding volume. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

Genetically Engineered Bacteria

A new frontier has developed as a result of advances in molecular biology. Recombinant DNA techniques have allowed the joining of DNA fragments from different organisms. Inserting these new DNA fragments into a bacteria give the cells new genetic information. The new instructions can cause the cell to produce chemical materials or perform conversions that were not normally part of its former life function. Although this technology is in its infancy, great benefits have already been derived from its application. The synthesis of human insulin and other hormones, and the production of vaccines and vitamins are just a few of the commercial applications.

The major drawback with this technology is the potential danger and controversy associated with the creation of these new life forms. Synthesis reactions involving genetically engineered bacteria are carried out in closed vessels. The bacteria are "sterilized" or removed before the products are recovered to prevent environmental release. The application of genetically manipulated bacteria to waste or in situ treatment is currently restricted until the controversy and safety issues are resolved. Only one commercial application of environmentally released, genetically engineered bacteria has been allowed to date. This was a test involving a bacteria engineered to prevent frost damage to strawberries. Until the controversy and safety issues are resolved, further development for waste treatment applications are at a standstill.

Genetically engineered bacteria are unavailable for the treatment of the types of dissolved chlorinated organics in the Firestone Salinas ground water. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.6 Composting

Composting is an aerobic treatment method used to treat primarily high solids sludges or solid waste. The method involves simply piling organic-containing waste and allowing natural aerobic bacteria to grow and decompose the solid waste material. Refinery sludges and municipal sludges may be effectively treated this way. Often this method is referred to as landfarming. Turning over piles (tilling) enhances bacterial action and growth and serves to aerate the soil. Adding lime helps condition the soil and balance the pH. Nutrients may be added to encourage optimum bacterial growth and waste breakdown. The products are gases, usually carbon dioxide and steam, and a liquid leachate which may contain partially oxidized organics or heavy metals (Berkowitz et al., 1978). If the waste contains primarily organic constituents, sludge disposal from the compost bed will not be necessary. The organics will be either completely oxidized and be removed as gases or left in the leachate. Compost piles must be slightly wet for the bacteria to begin functioning. Usually enough water is produced by the decomposition to sustain the bacteria until the composting is completed. Composting will also proceed anaerobically, as demonstrated in municipal landfills. The products from anaerobic composting are methane, some carbon dioxide, traces of volatile organics, and water. On a large scale, methane is usually extracted by installing wells in the landfill. The gas is then recovered, purified, and sold as a medium to high BTU gas product. The primary costs involved in composting are transportation to the composting site, labor and equipment costs to move and till waste material, collection and disposal (or treatment) of leachate, and the cost of a land parcel and any necessary improvements. Improvements may include a concrete slab or liner to assist leachate collection and prevent ground-water contamination.

Composting would not be applicable to treatment of the Firestone Salinas ground water since it is only a treatment method suitable for solid waste material. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.3.7 Aquaculture

A novel treatment method for treating relatively dilute aqueous wastes is aquaculture treatment. Several species of aquatic plants are well adapted for absorbing waste materials from waste streams; in particular, those wastes containing nutrients such as available nitrogen and phosphorous. Water hyacinths are a menace when they clog navigation channels. However, the characteristics that make them a menace in open waters make them ideal for waste treatment. These plants are rapid growing. They have long, fine filamented roots that hang down as deep as 4 feet from the floating plant on the surface. Allowing these plants to grow over a large treatment lagoon provides an efficient way to detoxify large volumes of waste water. The root filaments trap or consolidate fine particulates which settle to the bottom of the basin. The plants absorb soluble pollutants and incorporate them into plant mass. BOD, suspended solids, and metals can be reduced by hyacinth treatment. Not all pollutants are destroyed, some being concentrated in the plant tissues. Also, periodic harvesting of the plants is necessary. The plants are much easier to handle and dewater than conventional sewage sludges. The plants are non-odorous and can be transported in dump trucks. They are self-dewatered when placed in a landfarm and biodegrade aerobically. The application of aquaculture is competitive with other processes. The technology is not as suitable for cold climates. Lower temperatures slow down the growth rate of the plants. Also, prolonged freezing temperatures will kill off unprotected plants. The simplicity and added benefits of this technology make it attractive. However, aquaculture is still an emerging treatment method (Hesby, 1983). There is limited data available on the ability of the plants to remove synthetic organic hydrocarbons.

Aquaculture treatment would not be appropriate for treatment of the Firestone Salinas ground water. The large land area required for treatment ponds, the low concentrations of nutrients in the ground water, and unconfirmed ability of the cultivated plants to treat or remove chlorinated organics make the method unsuitable and uneconomical. Thus, no further consideration will be given to this treatment method for implementation at the Firestone Salinas site.

2.4.4 Thermal Treatment

Thermal treatment is destruction of hazardous waste materials (solid, liquids, gases, sludges, tars, etc.) by high-temperature heating. There are a number of different thermal treatment technologies. These can be grouped into the following five categories:

- Thermal oxidation (incineration)
- Thermal degradation (calcination)
- Vitrification (glass encapsulation)
- Plasma pyrolysis (complete atomic disassociation)
- Nuclear destruction (fission, fusion, or high energy bombardment reactions causing sub-atomic disassociation).

Thermal treatment would not be economical for treatment of the dilute concentrations of chlorinated organic hydrocarbons in the Firestone Salinas ground water. However, for information purposes, brief discussions of each of the methods are presented.

2.4.4.1 Thermal Oxidation (Incineration)

Thermal oxidation is the reaction of waste material with oxygen in the gas phase. This is a common treatment method for liquids such as solvents, fuels, oils, etc. It is also appropriate for combustible gases and solids (such as municipal trash or rubber scrap). Treatment is performed in units designed with good air flow and adequate residence time to allow for complete destruction. Units may have additional fuel sources to maintain temperature when treating low BTU waste material. Thermal oxidation units include liquid injection incinerators, industrial boilers, and kilns (for some wastes), rotary kiln incinerators, fluidized bed incinerators (relatively new technology), fixed or multiple hearth incinerators (used for incineration of municipal waste) and flare stacks. Operating temperatures are usually in the range of 1,600 to 2,400°F.

2.4.4.2 Thermal Degradation (Calcination)

Thermal degradation or calcination is a process that degrades waste materials by thermally induced chemical transformations other than oxidation. The process is best suited for solid waste treatment. During calcination, water and organics are driven off, and the organics are thermally destroyed. Reaction gases may also be driven off, such as hydrogen sulfide or carbon dioxide. The inorganic waste material remaining after treatment is in a more suitable form for disposal. The process is suitable for treating contaminated soils, certain concentrated liquids, sludges, and tars. The process has also proven effective for the concentration and solidification of radioactive waste liquids and solids. The process is used commercially in smelting of some ores and manufacture of cement products. Unit configurations include rotary kiln furnaces, fluidized beds units, open and multiple hearth furnaces, and refinery coker units. Operating temperatures are in the range of 1,200 to 2,500°F (Berkowitz et al., 1978).

2.4.4.3 Vitrification

Vitrification is a combination thermal treatment process and encapsulation process. Waste materials are mixed with appropriate inorganic refractories (silica, alumina, etc.) or simply heated (depending on the waste material). The material is heated hot enough to melt or fuse the inorganic components into a glass. The waste material is either micro encapsulated by the glass or reacts to help form the glass. Organic components in the waste are driven off and thermally destroyed. The waste after treatment is stable and suitable for land burial. Units for vitrification treatment include rotary kilns, molten salt units, and molten glass furnaces. Operating temperatures depend on the materials to be treated but are usually high.

An alternate version of This process is in situ vitrification. In this process electrodes are inserted into the ground with a graphite linkage between the electrodes. A current is applied that heats the graphite. Eventually the graphite is hot enough to melt and fuse the inorganics to form a molten vitrified glass. Once molten, the glass acts as the conductor and the graphite burns off. Organics may be destroyed or driven off. Leachable inorganics are either fused or encapsulated. Melts as large as 800 tons have been performed. Treatment of soil to depths of 50 feet is being considered. The economics are competitive with alternative treatments.

The glass may take as long as a year to cool and there are some other technical considerations. The process is a promising method for treatment of radioactive wastes and waste sites where digging up of soils would be hazardous or impractical. The process can generate in soil temperatures in excess of 3,600°F (Buelt et al, 1982).

2.4.4.4 Plasma Pyrolysis

Plasma pyrolysis is an emerging treatment method that destroys a waste by passing it through a plasma gas stream. An electrode assembly is used to energize a gas stream. The gas reaches temperatures between 5,000° and 15,000°C. Liquid waste heated by the plasma is completely disassociated. It then reforms into gases, such as carbon monoxide, nitrogen, carbon dioxide, hydrogen, etc. The gases are scrubbed, then flared to the atmosphere. Destruction efficiency is extremely high. Currently the technology is limited to pumpable liquids at treatment rates of about 3 gpm. Energy consumption is high (Cheremisinoff, 1988).

2.4.4.5 Nuclear Destruction

Uncontrolled thermonuclear reactions produce temperatures exceeding 20 million degrees centigrade. There is no doubt that complete destruction of waste materials would occur at these temperatures. Although an uncontrolled nuclear reaction is absurd for use as a waste treatment method, development of controlled fusion technology may provide an answer to conventional and radioactive waste problems in the future. Nuclear reactors and high energy physics units may be used to convert some dangerous, long lived isotopes into shorter lived, less hazardous species. Currently this is not economical for large-scale treatment.

This method is also presented to show the progression of thermal treatment destruction mechanisms depending on the temperature and energy level. Destruction reactions at lower (energy) temperatures proceed by molecular rearrangement and breaking molecular bonds. Higher temperatures (increasing energy level) break materials down into atomic components (as is found in plasma processing). At still higher energy (nuclear) and temperatures, reactions occur at the subatomic level.

No further consideration will be given to any of the thermal treatment methods for implementation at the Firestone Salinas site.

2.4.5 Dispersed Treatment

The dispersed treatment option would locate treatment systems at remote locations near extraction wells. Each system would operate independently, although transmission of operations performance parameters may be sent to a central location or recorded remotely. Each treatment system would process ground water independently. It may be cost effective to combine some of the discharges from remote units into pipeline headers and send to single or multiple remote locations for discharge (i.e., the Salinas River). The number of treatment units would be determined by optimum pumping requirements and well locations.

There are several disadvantages to dispersed treatment. Multiple treatment units would require added sampling to verify performance of each system. Maintenance and labor costs would be increased in order to attend to multiple pieces of equipment (performing the same function). Security at multiple remote locations would be more difficult to maintain. The large land requirements may make it difficult to obtain permission from property owners to utilize larger areas of their property.

Although additional costs may be incurred to install piping to a central location, these costs would be somewhat offset by the economics and greater efficiency with a single, larger treatment system. Installation of utilities at multiple locations to support operations would be more expensive than if utility services are provided to a single location.

Dispersed treatment would not be efficient or economical for treatment of Firestone Salinas ground water. Thus, no further consideration will be given to the dispersed treatment option for implementation at the Firestone Salinas site.

2.4.6 Centralized Treatment

The existing centralized treatment system has demonstrated that a central treatment system is secure and efficient. The existing centralized treatment system located within the Firestone Business Park has a proven performance and safety record. The location provides a high degree of security due to the presence of security at the Business Park entrance and operating personnel on a 7-days-per-week basis. The existing treatment system is attended during off hours by a telephone paging system tied into operations' monitors. Personnel are available at all times during off hours to respond. The operations record of this installation demonstrates performance that would likely be unmatched by multiple remote units.

A centralized treatment system is the only type of installed remediation equipment considered further for treatment of ground water at the Firestone Salinas site. Further evaluation is included in Sections 3.0 and 4.0.

3.0 DEVELOPING REMEDIATION ALTERNATIVES

3.1 RELEVANT SITE CHARACTERISTICS

The site characteristics relevant to the remediation of the affected ground water at the Salinas site include the aquifer system, the site hydrogeology, and the geochemical nature of the ground water. These characteristics are discussed in the following paragraphs. Appendix F provides additional data on aquifer characteristics.

The ground-water aquifer system in the immediate vicinity of the facility is within three interconnected zones that are designated shallow, intermediate, and deep. The shallow aquifer extends from the surface to a depth of about 90 feet. The intermediate zone is about 40 feet thick and is generally located from 100 to 140 feet below the surface. The deep aquifer system locally has four distinct zones at 200-, 300-, 400-, and 500-foot depths. The various water-bearing zones are separated from one another by clay or silt layers (aquitards) that have varying thicknesses and are locally discontinuous. Where the aquitards are thin or discontinuous, flow can occur between the aquifers above and below the aquitard. The shallow aquifer has limited use because of its limited capacity during drought years. The intermediate zone has limited use because it is not thick and, therefore, does not yield a large quantity of water. The deep zone is extensively developed for agricultural and some domestic use.

Ground water in the aquifer system around the Firestone site flows generally northwesterly. In the shallow aquifer (Figure 3-1), the local flow direction from the former Firestone facility is westerly. At a distance of about 3,000 feet to the west, the flow direction resumes the regional northwesterly trend. On the basis of the hydrogeologic work done for the remedial investigation, the pathways of chemical movement (Figure 3-2) appear to be limited laterally to local ground-water channels. The edges of these channels are of much lower permeability and act as an impediment to the lateral spread of chemicals in the ground water near the site. Within the layered vertical structure of the aquifers there are vertical components to the flowpaths as well. When the agricultural wells are pumping, they create a downward flow component between aquifers.

At the site itself and for a distance of about 3,000 feet to the west, the aquitard under the shallow aquifer prevents downward flow. However, the aquitard is discontinuous to the west, where there is a downward diffusion from the surface aquifer into the underlying intermediate zone. The result is that dissolved chemicals in the surface aquifer are mixed and diluted as they diffuse downward to and through the intermediate zone.

Still farther to the northwest, about 6,000 to 7,000 feet from the former Firestone facility, the aquitard under the intermediate zone thins and allows further diffusion downward into the uppermost, or 200-foot, unit of the deep aquifer. The subsequent zone of dilution in the deep aquifer extends about 1,500 to 2,000 feet to the northwest. Again, regional ground-water flow further dilutes the dissolved chemicals migrating downward from the shallow and intermediate units.

Finally, there is a vertical flow component between the 200-foot unit to the deeper units when the agricultural wells are pumping. Clay aquitard layers between the 200-, 300-, 400-foot, and deeper water-bearing units are locally discontinuous, allowing additional downward diffusion and subsequent dilution. This zone of diffusion begins about 2 miles northwest of the former Firestone facility.

Ground water has been sampled extensively throughout the area surrounding the site. Each of the agricultural and domestic wells within 4 miles downgradient (northwest) of the site was located, verified, and sampled where access was obtained. On-site and off-site monitoring wells were also installed to assess the horizontal and vertical extent of chemicals in the ground water and the horizontal and vertical flowpaths. As a result of these samples, combined with each of the other investigations done, the nature and extent of chemicals in the ground water have been defined.

Chemical analyses of the wells in the vicinity have provided a good understanding of the concentrations of each specific chemical in the list of chlorinated aliphatic hydrocarbons and volatile aromatic hydrocarbons given previously. Since the analyses have been repeated over time, a good history of the concentration changes in any given well exists. This history can be related, in some cases, to the performance of the shallow aquifer ground-water extraction wells and treatment plant. Finally, the concentration data, combined with the hydrogeologic investigations, have determined the vertical and horizontal extent of chemicals associated with the former Firestone facility in the ground water.

Of the ten indicator chemicals (Appendix G) defined by the California Department of Health Services (DHS) for study at the beginning of Firestone's cleanup activities, three have been detected most frequently in limited areas of the ground water: 1,1-DCA, 1,1-DCE, and 1,1,1-TCA (Appendix H). The latter two are the most reliable indicators of the presence of chemicals because they are found in more wells than is the 1,1-DCA. Samples taken during the beginning of the extraction well field and water treatment plant operations show, at worst, no increase in concentrations and, at best, a decrease in concentrations for each of these chemicals (Appendix I). This suggests that the extraction wells have stabilized the plume of contamination and are reducing the concentration levels in some areas. The largest reductions have been made in the on-site locations with the highest original concentrations.

Samples from monitoring wells and from agricultural, domestic, industrial, and municipal wells show that the chemical plume ends about 2½ miles from the former Firestone facility. The plume of chemicals in the ground water (chemicals detected above the method detection limits) can be described as follows, starting at the former Firestone facility:

- A narrow ellipse 3,000 feet long and 1,000 feet wide, in the shallow aquifer, flowing almost due west
- A second narrow ellipse 4,000-feet-long and 1,000-feet-wide, in the

intermediate zone, flowing northwest
- A third ellipse 7,000 feet long and 1,500 feet wide, in the deep aquifer, flowing northwest.

Plumes of 1,1-DCE and 1,1,1-TCA in the various aquifers are shown in Figures 3-3 through 3-8. The data upon which these plumes are based were collected in the first quarter of 1989. As shown in these figures, the plume is laterally confined to alluvial channels. This is discussed in detail in the Remedial Investigation report (IT, 1988a). These plumes and the extensive hydrogeological studies reported earlier are the basis for location of the extraction wells as discussed in Section 3.2.

Concentrations of 1,1-DCE and 1,1,1-TCA are used throughout this report as indicators of remedial trends for all the chemicals found at the site. The reasoning behind this is:

- Continual observations in the wells monitored suggest that concentrations of all chemicals will drop below their action levels, and often the detection limits as well, before 1,1-DCE levels reach the 6 ppb California DHS Action Level, the cleanup level chosen for this compound.

- Monitoring and reporting of 1,1,1-TCA levels is done because that compound is the precursor to 1,1-DCE actually found. The degradation of 1,1,1-TCA to 1,1,-DCE is discussed in Section 1.4.3 of this FS/RAP report.

3.2 EXTRACTION ALTERNATIVES

Review of the plume maps (Figures 3-3 and 3-4) shows that the currently operating, shallow aquifer extraction wells, S-7, S-8, S-10, S-11, M-1, IT-SE2, IT SE3, IT-SE4, and IT-SE5 are located in the areas of the shallow aquifer plume with the highest concentrations. (Extraction well S-9 is very shallow and is not currently operating.) Thus, no modifications of locations were needed for the shallow aquifer remediation.

The plume maps for the 120-foot aquifer (Figures 3-5 and 3-6) show some wells above the cleanup levels presented on page 2-6. Thus, a series of potential locations for extraction wells was considered to be installed into the intermediate (120-foot) aquifer. The potential well locations considered are shown as wells IT-IE-1 through IT-IE-10 in Figure 3-9. These wells were located on the basis of the following criteria:

- Relatively high concentrations of chemicals in the ground water
- Anticipated high-permeability geological flow channels (this will be confirmed during installation of the wells)
- Relative ease of access, where possible, for complete coverage of the plume.

From these potential locations, six combinations of well locations were analyzed. These combinations are listed in Table 3-1, and the well locations and flowrates are shown in Figures 3-9a through 3-9f. These combinations include configurations aligned along the axis of the chemical plume, perpendicular to the axis, a diamond pattern over the plume, and a cross with the long leg along the axis of the plume and the short leg across the axis.

Computer simulations were made for each of these combinations. The most efficient remedial alternative was Alternative 6, listed in Table 3-1. This alternative consists of five extraction wells aligned along the axis of the plume in the 120-foot aquifer.

This extraction alternative was used to develop the site-specific remedial action alternatives discussed in Section 3-5. Figures 3-10 through 3-13 show the extraction well locations for each remedial action alternative. The other extraction alternatives in Table 3-1 were screened from additional consideration.

3.3 TREATMENT ALTERNATIVES

The five treatment alternatives that have been identified as possible strategies to be evaluated for implementation at the Firestone Salinas site are as follows:

- Activated carbon treatment
- Air stripping

- Natural or enhanced dilution/degradation
- Combined strategies
- Agricultural spraying.

These will be discussed individually in this section and evaluated in detail as these alternatives are part of the site-specific remedial action alternatives in Section 4.0.

3.3.1 Activated Carbon Treatment

As part of interim remediation measures, Firestone installed two 20,000-pound capacity activated carbon adsorbers. These two units are piped to operate in series and have a continuous treatment capacity of 500 gpm. The units are charged with virgin activated carbon. Currently, a majority of the ground water pumped from the extraction wells, is routed through the carbon units, and returned to the Salinas River through a 14-inch diameter outfall. Monitoring of the concentrations of organic contaminants in the influent, between the beds, and effluent is used to determine the frequency of carbon replacement. Carbon replacement is a simple operation requiring minimal downtime. Spent carbon is sent for regeneration back to the supplier. The existing carbon unit has demonstrated high efficiency and reliability for the Firestone Salinas ground water. Thus, activated carbon treatment is appropriate, should continued treatment be required.

3.3.2 Air Stripping

An air stripper column was installed at the Firestone Salinas site as part of the interim remediation measures that were implemented. The intent of the air stripper originally was for pretreatment of ground water before processing through the carbon unit. The existing air stripper has performed exceptionally well and has demonstrated that air stripping treatment alone is capable of removing the volatile organic contamination in the Firestone Salinas ground water below the NPDES permit levels for discharge of water into the Salinas River. The Firestone Salinas air stripper has features that optimize performance and economy. These include a redistributor within the column, high efficiency tower parking, and a variable speed blower. Air stripping has demonstrated greater economy over carbon treatment. The local air district allows direct discharge of the stripper exhaust to the atmosphere within permitted limits.

The permitted limit and hydraulic capacity are the current limitations on the existing air stripper. The treatment capacity of the air stripper is currently limited to 180 gpm. The performance of the existing air stripper has demonstrated that air stripping is appropriate, should continued treatment be required.

3.3.3 Natural Biological Degradation/Dilution

Natural biological degradation of most chlorinated synthetic organics occurs very slowly in the environment. The problem is two-fold. First there are limited bacterial species that can perform this type of conversion. Some chlorinated organic compounds are not degraded to any significant degree in the environment because they are not usable by the available natural bacteria. Enhancing bacterial action by supplying a specific strain is limited to finding suitable strains of bacteria that will perform the conversion.

The second problem is the deficiency of nutrients to stimulate bacterial growth. Chlorinated organics are usually found in very dilute concentrations when released into the environment. Without additional nutrients, natural bacteria grow and reproduce very slowly. The limited numbers of cells would degrade chlorinated organic materials at a very slow rate. Aromatic hydrocarbons also occur in very dilute concentrations in a limited area of the site. They can be degraded, but they are not widespread throughout the plume. They occur primarily near the southwest corner of the building.

Due to these two limiting factors, relying only on natural degradation of the chlorinated organics in the Firestone Salinas ground water would require many years for concentrations in the ground water to return to acceptable levels.

The aquifers beneath the Firestone site are high quality and possess reasonable permeability. Natural dilution, removal, and recharge will be the primary means for lowering organic concentrations in the various aquifers. Even without operation of extraction wells, tremendous quantities of water are removed from beneath the site by agricultural water wells. Some of these wells draw from both shallow and deep aquifers. Additionally, natural recharge of the aquifer from the Salinas River and from the surrounding mountains dilutes ground water significantly. Although the process may require several years, natural and induced dilution and flushing of the aquifer would eventually bring organic contamination levels down to acceptable levels.

3.3.4 Combined/Additional Strategies

Under the interim remediation strategy, an air stripper and an activated carbon unit were installed to be operated in series (Figure 3-14). Two processing units were proposed for economy and environmental protection. Air stripper treatment before carbon treatment of a process stream would extend the life of the carbon significantly. Since operation began, it was demonstrated that air stripping or carbon treatment alone are both effective in removing the volatile contamination in extracted ground-water streams. Balancing of flows by directing streams with high concentrations preferentially to the air stripper has maximized plant treatment capacity and minimized carbon changeout cost. The current plant capacity is 650 gpm and requires carbon changeouts only twice per year, with the current concentrations.

Air stripping is more economical and equally effective as carbon treatment. In hindsight, the carbon unit would not be necessary providing an air permit were obtainable to discharge all pollutant exhaust from a larger air stripper to the atmosphere. However, to meet treatment capacity requirements, the economics does not justify replacement of the existing carbon unit with a new air stripper this late in the project (based on projected cleanup scenarios).

Other possible combined treatment alternatives, although effective, would not be economical when compared against the inherent value and operating cost of the existing treatment system.

3.3.5 Agricultural Spraying or Flooding

Aeration by agricultural spraying or flooding is a simple means to remediate the ground water. This is currently being done defacto from the deep aquifers on an intermittent basis. There are, however, several restrictions that limit the usefulness of this alternative as a continuous process.

Agricultural consumption of water will not coincide with the water supply, thus requiring storage of water or shutdown of wells. Agricultural spraying is only performed on young crops. Furrow irrigation is the preferred method of irrigation for most of the growing season. Agricultural spraying or flooding is a good way to utilize extracted ground water, but again the demand is not always constant.

The hydrogeology of the area shows that the Salinas River as well as the surrounding mountains recharge the underground aquifers. Pumping treated water to the river simply returns the ground water to be used as required by agricultural consumers upon demand. Simply pumping to the river is more cost effective and minimizes any adverse public reaction to other water uses. Agricultural spraying is considered further in Section 4.0, with respect to the deep aquifer.

3.4 DETAILED ANALYSIS OF DISPOSAL ALTERNATIVES

This section briefly describes and analyzes disposal alternatives for the treated ground water at the former Firestone facility. These disposal alternatives are as follows:

- Alternative S: Stream disposal - Section 3.4.1
- Alternative T: Injection - Section 3.4.2
- Alternative U: Holding ponds, lagoons, or basins - Section 3.4.3

The discussion for each disposal alternative includes identification and summary of the alternative, advantages and disadvantages of the alternative, and the procedure for monitoring treatment plant affluent concentrations.

3.4.1 Alternative S - Stream Disposal

Alternative S is the discharge of treated ground water to the Salinas River channel. This is the alternative implemented during the interim remedial measures started in February 1986 and continuing to the present (1989).

This alternative consists of pumping the treatment plant effluent into a pipeline, approximately 1 mile long, which runs from the treatment facility at the former Firestone facility to a discharge point at the Salinas River. An NPDES permit was obtained for a maximum discharge of 1000 gpm and startup flows not to exceed 250 gpm. The Salinas River generally has limited flow. During the high water seasons, the river flows directly into the Monterey Bay; however, the majority of the time the river is intermittent and water infiltrates into the ground before it reaches the bay.

Discharging into stream channels has been used for many years for the disposal of various treated waste water. There are several advantages of this disposal alternative. The treated wastewater at the former Firestone facility consists of clean water and is returned for future use. That is, there is no consumptive use of the water, except for a very small loss in the air stripper and in the effluent tank (14 gallons out of 775,000 gallons treated daily). Clean water returned to the aquifer does not place limitations on the water use, which is an important advantage of this alternative. Another advantage of this disposal alternative is that the NPDES permit required for disposal has already been issued. It will only require renewal.

A disadvantage of this alternative is that there is a small loss of water through evaporation and evapotranspiration after the water is discharged into the Salinas River and before it infiltrates into the river bed.

For this alternative, the discharge water is monitored at the treatment facility and at the river outfall, and discharge into the river would be discontinued immediately, if effluent concentrations were found to exceed limits listed in the NPDES permit.

3.4.2 Alternative T - Injection

Alternative T consists of injection of the treatment plant effluent into the aquifer from which it was withdrawn. The injection of liquid wastes, in this case treated ground water, has been widely adopted as a common waste disposal practice in the United States. The most common type of injection well is that used to return brine extracted during oil and gas field pumping. The purpose of the procedure is to isolate the substance from the biosphere. In the case of injection wells at the former Firestone facility, the purpose would be to return clean usable water to the aquifer for downgradient uses.

The advantages of injection are that there is no evaporation of the water, clean water returned to the aquifer does not place limitations on water use, and discharge pipelines can be avoided.

However, there are several drawbacks in the use of injection wells for disposal. Well plugging is very common and requires that the well be taken out of service and treated before it can be returned to use. An example of this type of problem occurred at the Ashworth Brothers Metal Plating Co. located approximately 3 miles upgradient of the former Firestone facility. Additionally, if water with different chemical characteristics is returned to an aquifer, the result can be the dissolution of unwanted minerals that can degrade the quality of the ground water, possibly affecting its use. This alternative would require a new NPDES permit and, consequently, preparation of the associated application documents, public hearings, meetings, and the required time for regulatory review.

For this alternative, the water being discharged into the injection well would be monitored at the treatment facility, and discharge would be discontinued immediately, if effluent concentrations were found to exceed limits listed in the NPDES permit.

3.4.3 Alternative U - Holding Ponds, Lagoons, or Basins

Alternative U consists of discharging the treatment plant effluent into holding ponds, lagoons, or basins, which allow the water to infiltrate into the ground and to evaporate. This type of operation has been a common waste disposal practice for many years. The liquid waste, in this case treated ground water, is placed in unlined ponds, lagoons, or basins and allowed to infiltrate into the ground or to evaporate, either directly or by evapotranspiration. The reason for using this method at the former Firestone facility would be to return clean, usable water to the aquifer for downgradient uses.

Ponds, lagoons, and basins have been used for many years for the disposal of various treated waste water. The following are some of the advantages. The treated waste water, which consists of clean water at the former Firestone facility, is returned for future use. Clean water returned to the aquifer does not place limitations on water use, and extensive discharge pipelines can be avoided.

The major drawback in the use of this alternative for waste water disposal at the former Firestone facility is the potential flooding of some of the nearby farmland, which is at a lower elevation than the holding ponds, lagoons, or basins. Crops with critical water needs are grown near the facility and could be harmed by excessive water. Additionally, during harvest times, saturated ground would make the use of farm equipment difficult. A further concern would be the plugging of the bottom of the ponds, lagoons, or basins. This would require that the operation be stopped until the problem was corrected. Also, the chemical characteristics of the water can change as it percolates downward. The result can be the dissolution of unwanted natural minerals that can degrade the quality of the ground water, thereby making it unusable. Also, water can be lost for reuse by evaporation or evapotranspiration. This alternative would require a new NPDES permit, with the concomitant public hearings, meetings, and time required for regulatory review, (minimum of 180 days).

For this alternative, the water being discharged into the ponds, lagoons, or basins would be monitored at the treatment facility and at the outfall with discharge being discontinued immediately if effluent concentrations are found to exceed limits listed in the NPDES permit.

3.4.4 Summary of Discharge Alternatives

Alternative S, discharge of treated ground water to the Salinas River, is considered the most appropriate and the most time and cost-effective disposal alternative for the Firestone site, based on IT's analysis of the three alternatives. Alternative S is protective of the environment, returns a natural resource for future use, and does not have the potential environmental problems associated with Alternatives T and U. Alternative S returns clean water to the aquifer, and the NPDES permit required for this disposal alternative has already been issued. The discharge water is monitored at the treatment facility and at the river outfall, and discharge into the river is discontinued immediately if effluent concentrations are found to exceed limits established in the NPDES permit.

Alternative T consists of injection of the treatment plant effluent into the aquifer from which it was withdrawn. Although Alternative T returns water to the aquifer, there are a number of potential problems associated with this alternative, including the following:

- Well plugging is very common.
- Injection of water with different chemical characteristics into the aquifer can result in dissolution of unwanted minerals and degradation of ground-water quality.

Alternative T would require a new NPDES permit (minimum of 180 day processing). Potential well plugging would increase down time for the treatment plant.

Alternative V consists of discharging the treatment plant effluent into holding ponds, lagoons, or basins, which allow the water to infiltrate into the ground or to evaporate. This alternative would also return water to the aquifer, but potential environmental drawbacks include the following:

- Potential flooding of nearby farmland
- Potential adverse effects of excessive water, including effects on crops with specific water requirements and difficulties in the use of farm equipment on saturated ground
- Potential for plugging of the bottom of the ponds, lagoons, or basins
- Potential for dissolution of unwanted minerals and degradation of ground-water quality.

This alternative would also require a new NPDES permit, with the concomitant public hearings, meetings, and time required for regulatory review (minimum of 180 days).

3.5 SITE-SPECIFIC REMEDIAL ACTION ALTERNATIVES

As discussed in the previous sections, the treatment alternatives have been screened to carbon adsorption, air stripping, or a combination of these. The disposal options were screened to discharge into the Salinas River. The extraction alternatives consist of combinations of pumping from the shallow and intermediate aquifers, and different schedules to initiate pumping from each aquifer.

The experience gained from operating the interim remedial measures since early 1986 demonstrates that the recovery can be optimized by allowing the site manager a large degree of flexibility in adjusting the flowrates in the individual wells on the basis of the monitoring data. The general criteria used by the site manager are as follows:

- Maximize the flowrate from affected wells up to a combined flowrate equal to the treatment plant capacity
- Cycle the pumping rate, if this proves to be efficient in remediation

- Pump the highest flow from the wells with the highest concentrations of chemicals
- Discontinue pumping as the concentrations in a well decrease to the cleanup levels, and possibly sooner if there is an adjacent or downgradient well that will capture the chemicals faster
- Direct the flowstream with the highest concentrations to the airstripper and the lowest flowstream to the carbon adsorption unit.

These procedures allow maximizing the recovery from the aquifer.

3.5.1 Approach

The primary objective of the feasibility study remedial action plan is to ensure that appropriate remedial alternatives are developed and evaluated that protect human health and the environment and are appropriate to the site's problem. The EPA Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (March 1988, hereinafter referred to as EPA RI/FS guidance document) provides guidance for development of alternatives. Although the risk assessment (IT, 1988b) has shown there is no unacceptable health or environmental risk, this guidance document was followed.

Alternatives for remediation are developed by assembling combinations of technologies into alternatives. This process of six general steps is briefly discussed below:

STEP 1 - Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of treatment and containment alternatives to be developed. The objectives developed are based on contaminant-specific ARARs, when available, and risk-related factors.

STEP 2 - Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial action objectives for the site.

STEP 3 - Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site.

STEP 4 - Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site. The general response actions are further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include chemical or biological technology types).

STEP 5 - Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

STEP 6 - Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

Step 1 has been performed in the RI. The other steps are discussed in Section 2.0 of this FS/RAP. The remaining activity required in developing alternatives is combining and assembling representative technology process options to specific alternatives. At a minimum, EPA guidance states that at least one representative process option from each technology identified as potentially applicable should be developed.

The "Site Mitigation Decision Tree" and the current NCP rule state that developed alternatives should include the following:

- A no-action alternative
- Alternatives involving off-site treatment or disposal
- Alternatives that attain applicable or relevant public health or environmental standards
- Alternatives that exceed applicable or relevant public health or environmental standards
- Alternatives that do not attain applicable or relevant public health or environmental standards but which meet CERCLA's objective of adequately protecting public health, welfare, and the environment.

The proposed rule and draft guidance do not specify that alternatives identify different levels of ARAR attainment, but rather concern themselves with the time required to reach remediation goals. The proposed rule was considered in this FS/RAP because it indicates current regulatory direction.

This FS/RAP study is limited to the remediation of contaminated ground water. As such, the remediation effort can be considered to be a ground water response action. The draft EPA RI/FS guidance document states that:

> For ground water response actions, alternatives should address not only cleanup levels but also the time frame within which the alternatives might be achieved. Depending on specific site conditions and the aquifer characteristics, alternatives should be developed that achieve ARARs or other risk-based levels determined to be protective within varying time frames using different methodologies. For aquifers currently being used as a drinking water source, alternatives should be configured that would achieve ARARs or risk-based levels as rapidly as possible.

The NCP proposed rule states that a limited number of remedial alternatives utilizing one or more technologies that attain site-specific remediation levels within different time frames should be developed. Also, the no-action alternative should be developed. If there is reason to believe that innovative technologies may provide superior performance compared to demonstrated technologies, these should also be developed. No innovative technologies are known to exist for which an alternative should be developed for the Salinas site.

3.5.2 Developed Alternatives

For the site-specific remedial action alternatives developed in this FS/RAP, we propose that the site manager continue to apply the criteria listed in Section 3.5 to optimize the aquifer restoration. The screened alternatives from this FS/RAP are discussed in detail in Section 4.0. The following paragraphs outline the alternatives.

Alternative A is the no action alternative. This alternative is required by regulatory guidelines and is considered as a baseline alternative. This alternative consists of discontinuing the current extraction and treatment. The monitoring wells would continue to be monitored until 2 years after the ground-water cleanup levels are achieved by natural dilution, degradation, and diffusion.

Alternative B consists of continuing to extract and treat ground water from the shallow aquifer. No extraction will be done in the intermediate aquifer. The pumping will stop when the shallow aquifer extraction wells show concentrations have remained below the ground-water cleanup levels. Treatment will consist of combined air stripping and carbon adsorption when the flowrate is over 180 gpm and air stripping only when the flowrate is less than 180 gpm. In each of these cases, the effluent is discharged into the Salinas River. Monitoring will continue in the shallow and intermediate aquifers until the concentrations have remained below the ground-water cleanup levels for two uninterrupted years.

Alternative C consists of continuing to extract and treat ground water from the shallow aquifer and simultaneously pumping and treating ground water from the intermediate aquifer. Each well in this alternative will be pumped at its maximum capacity. This will result in a combined flowrate that exceeds the current treatment plant capacity of 650 gpm. Thus, a new 500 gpm air stripper will be installed. Extraction will continue in each well at the maximum flowrate until the ground-water cleanup levels are achieved in both the shallow and intermediate aquifers. Treatment will consist of combined carbon adsorption and air stripping with the existing air stripper as well as with a new air stripper. The effluent will be discharged into the Salinas River. Monitoring will continue in the shallow and intermediate aquifers until the concentrations have remained below the ground-water cleanup levels for two uninterrupted years.

Alternative D consists of continuing to extract and treat ground water from the shallow aquifer and simultaneously pumping and treating ground water from the intermediate aquifer, as in Alternative C. However, for Alternative D, all the wells will not be pumped at their maximum flowrate. Rather, the combined flowrate will be maintained at or below the capacity of the existing treatment plant of 650 gpm. Thus, no modification of the treatment plant will be needed.

Extraction will continue until the ground-water cleanup levels are achieved in both the shallow and intermediate aquifers. Treatment will consist of combined carbon adsorption and air stripping with the existing treatment plant. The effluent will be discharged into the Salinas River. Monitoring will continue in the shallow and intermediate aquifers until the concentrations have remained below the ground-water cleanup level for two uninterrupted years.

Alternative E consists of continuing to extract and treat ground water from the shallow aquifer and simultaneously pumping and treating ground water from the intermediate aquifer, like Alternatives C and D. However, only two new extraction wells will be installed in the intermediate aquifer. This will result in a combined flowrate of less than the current treatment plant capacity of 650 gpm. Extraction will continue in each well at the maximum flowrate until the ground water cleanup levels are achieved. Treatment will consist of combined carbon adsorption and air stripping with the existing air stripper as long as the flowrate exceeds 180 gpm. At flowrates below 180 gpm, only the airstripper will be used. The effluent will be discharged into the Salinas River. Monitoring will continue in the shallow and intermediate aquifers until the concentrations have remained below the ground-water cleanup levels for two uninterrupted years.

4.0 DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES

This section presents a detailed analysis of the alternatives assembled and described in Section 3.0, Developing Remediation Alternatives. These alternatives are analyzed for their effect on the mitigation of chemicals in the ground water. The scope of treatment alternatives for this FS is limited to the use of air stripping and carbon filters based on the treatment screening presented in Section 2.0. The various pumping alternatives developed in Section 2.0 have been combined with treatment alternatives to develop a limited number of remediation alternatives for aquifer restoration in Section 3.0. As a result, the alternatives developed in Section 3.0 are limited to five based on the initial screening.

The purpose of the detailed analyses of alternatives is to analyze and present relevant information to allow comparison of alternatives, selection of an appropriate remedy, and demonstration of satisfaction of the statutory requirements in the ARARs.

The criteria utilized to evaluate alternatives are presented in Section 4.1. The current NCP rule states that refinement and specification in detail of alternatives which remain after the alternative screening steps have been performed are required as part of the detailed analysis of alternatives. Each alternative is further developed in Section 4.2. An evaluation and comparison of alternatives for each criteria are presented in Section 4.3. A summary of the detailed analyses is presented in Section 4.4.

4.1 DETAILED ALTERNATIVE ANALYSES CRITERIA

The following current and proposed regulations and guidance documents have been reviewed to determine appropriate criteria to be utilized in performing the detailed analysis of alternatives:

- California Department of Health Services, 1986, the California Site Mitigation Decision Tree Manual, Toxic Substances Control Division, Alternative Technology and Policy Development Section, May.

- EPA, 1982, The National Oil and Hazardous Substances Pollution Contingency Plan under CERCLA, as amended, 47 FR 31203, July 16.
- EPA, 1985b, "Guidance on Feasibility Studies Under CERCLA," EPA/540/G-85/003, June.
- EPA, 1988a, "Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," OSWER Directive 9335.3-01, March.
- EPA, 1988c, The National Oil and Hazardous Substances Pollution Contingency Plan, proposed rule, 53 FR 51394, December 21.

The current NCP rule states that the detailed analysis of alternatives shall include the following components:

- Detailed cost estimation, including operation and maintenance costs, and distribution of costs over time
- Evaluation in terms of engineering implementation, reliability, and constructibility
- An assessment of the extent to which the alternative is expected to effectively prevent, mitigate, or minimize threats to, and provide adequate protection of public health and welfare and the environment. This shall include an evaluation of the extent to which the alternative attains or exceeds applicable or relevant and appropriate federal public health and environmental requirements. Where the analysis determines that federal public health and environmental requirements are not applicable or relevant and appropriate, the analysis shall, as appropriate, evaluate the risks of the various exposure levels projected or remaining after implementation of the alternative under consideration.
- An analysis of whether recycle/reuse, waste minimization, waste biodegradation, or destruction or other advanced, innovative, or alternative technologies is appropriate to reliably minimize present or future threats to public health or welfare or the environment
- An analysis of any adverse environmental impacts, methods for mitigating these impacts, and costs of mitigation.

The DHS Decision Tree states that five criteria are utilized in the detailed analysis of alternatives. The criteria are technical, institutional, cost, public health, and environmental impact analysis. The criteria presented in the Decision Tree were based primarily on two EPA publications available at the time. These two documents are "Draft Methodology for Screening and Evaluation of Remedial Responses" (prepared by JRB Associates, McLean, VA for EPA Municipal Environmental Research Laboratory, Cincinnati, Ohio; and EPA Office of Emergency and Remedial Response, Washington, D.C., March 16, 1984) and "Guidance on Feasibility Studies under CERCLA" (EPA, 1985b).

Although the proposed NCP rule revision at 53 FR 51394 has not been promulgated and the March 1988 RI/FS guidance document has only been issued as a draft document, these documents provide information on the current direction of EPA regulations and guidance. DHS recommended that these recent EPA guidance and rules be followed preferentially over the California Site Mitigation Decision Tree Manual when the two documents conflicted (William Owen DHS, personal communication, March 15, 1989).

The preamble to the proposed NCP rule revision states "the RI/FS process proposed today incorporates statutory requirements, reflects the program management principles of the bias for action, streamlining, and site management planning, and builds on the engineering and analytical steps established in the current NCP." The proposed rule includes criteria presented in the DHS Decision Tree and the current NCP rule in a revised format based on previous experience. The proposed rule criteria are utilized for the detailed evaluation of alternatives for this FS/RAP.

The NCP proposed rule defines nine criteria for alternative evaluation as follows:

> (A) Overall protection of human health and the environment. Alternatives shall be assessed as to whether they can adequately protect human health and the environment from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals. This is a threshold requirement and the primary objective of the remedial program.

(B) Compliance with ARARs. The alternatives shall be assessed as to whether they attain applicable or relevant and appropriate requirements (ARARs) of other Federal and State environmental and public health laws or provide grounds for invoking one of the waivers included in the proposed rule. Compliance with ARARs is a threshold requirement. All alternatives remaining in the final analysis shall meet ARARs or obtain ARAR waivers.

(C) Long-term effectiveness and permanence. Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include the following:

(1) Nature and magnitude of total residual risks in terms of amounts; potential for exposure of human and environmental receptors; concentrations of hazardous substances, pollutants, or contaminants remaining following implementation of a remedial alternative, considering the persistence, toxicity, mobility, and propensity to bioaccumulate such hazardous substances and their constituents

(2) The type, degree, and adequacy of long-term management required for untreated substances and treatment residuals, including engineering controls (such as containment technologies), institutional controls, monitoring and operating, and maintenance

(3) Long-term reliability of the engineering and institutional controls, including uncertainties associated with land disposal of untreated hazardous substances, pollutants, and contaminants, and treatment residuals

(4) Potential need for replacement of the remedy, as well as the continuing need for repairs to maintain the performance of the remedy.

(D) Reduction of toxicity, mobility, or volume. The degree to which alternatives employ treatment that reduces toxicity, mobility, or volume shall be assessed. Alternatives which, at a minimum, address the principal threats posed by the site through treatment shall also be identified. Factors that shall be considered, as appropriate, include the following:

(1) The treatment processes the alternatives employ and materials they will treat

(2) The amount of hazardous substances, pollutants, or contaminants that will be destroyed or treated

(3) The degree of expected reduction in toxicity, mobility, or volume, including how the principal threat is addressed through treatment

(4) The degree to which the treatment is irreversible

(5) The residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate such hazardous substances and their constituents.

(E) Short-term effectiveness. The short-term impacts of alternatives shall be assessed considering the following:

(1) Short-term risks that might be posed to the community during implementation of an alternative

(2) Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures

(3) Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation

(4) Time until protection is achieved.

(F) Implementability. The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

(1) Degree of difficulty or uncertainty associated with construction and operation of the technology

(2) Expected operational reliability of the technologies the alternatives utilize and the ability to undertake additional action, if required

(3) Ability and time required to obtain any necessary approvals and permits from other agencies

(4) Availability of necessary equipment and specialists

(5) Available capacity and location of needed treatment, storage, and disposal services

(6) Timing of the availability of prospective technologies that may be under consideration.

(G) Cost. The types of costs that shall be assessed include the following:

(1) Capital costs, including contingency and engineering fees

(2) Operation and maintenance costs

(3) Net present value of capital and O&M costs.

(H) State and/or support agency acceptance. Assessment of State concerns may not be completed until comments on the RI/FS are received and may be discussed, to the extent possible, in the proposed plan issued for public comment. The State concerns that shall be assessed include the following:

(1) The State's and/or support agency position and key concerns related to the preferred alternative and other alternatives

(2) State and/or support agency comments on ARARs or the proposed use of waivers.

(I) Community acceptance. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the proposed plan are received.

The EPA RI/FS guidance document presents these nine criteria and expands on them. The first two criteria, overall protection of human health and the environment, and compliance with ARARs, are termed threshold criteria in that these items are evaluated as to whether, and how, the criteria are met as opposed to the next five criteria for which they are evaluated on a continuum. In particular, alternatives that do not protect human health and the environment, or do not comply with ARARs (or justify a waiver), will not meet statutory requirements for selection of remedy in the Record of Decision (ROD). The final two criteria for State (and/or support agency) acceptance and community acceptance are only preliminarily analyzed in the RI/FS. These criteria are formally addressed after the completion of the FS and the formal public hearing/comment period.

4.2 ALTERNATIVE DESCRIPTION

The five alternatives presented in Section 3.0 are developed and described in further detail in this section. Table 4-1 presents the alternatives versus potentially applicable or relevant and appropriate requirements, and Table 4-2 summarizes the detailed analysis of remediation alternatives. A cost comparison of the assembled remediation alternatives is presented in Figure 4-3.

4.2.1 Alternative A

Alternative A is the "No-Action" alternative. This is required by regulation and is considered as a baseline alternative. The "no-action" alternative is defined as being the current site conditions, absent the ongoing remedial measures. The ongoing remedial measures that started in February 1986 consist of pumping and treating the ground water with carbon adsorption and air stripping, and discharging the treated water to the Salinas River under an NPDES permit.

This alternative consists of stopping the pumping and treating that is taking place now. Monitoring will continue under this alternative until the chemical concentrations in each of the wells decrease to below the ground-water cleanup levels. Then, monitoring will continue for an additional two years to assure that no concentrations above the cleanup levels occur (see Section 5-2). However, this alternative does include maintaining the treatment plant in a standby mode for two years, ready to be placed back in service if necessary. After two uninterrupted years with no concentrations above the cleanup levels, all or portions of the treatment plant may be dismantled and salvaged. At this point, some of the monitoring and extraction wells may be abandoned according to state and local requirements. Sufficient wells will be retained to provide data for the 5-year review required by CERCLA Section 121(c).

For this alternative, the treatment plant will not be operated.

This discussion of Alternative A is not meant to imply that no-action will clean up the aquifer, rather that after some time, the observed concentrations of chemicals in the aquifer will decrease to below the ground-water cleanup levels due to natural attenuation, degradation, and diffusion.

Computer simulations have been made for Alternative A. The program used for these simulations and the input parameters are discussed in Appendix J. The model areas are shown in Figure 4-1. The migration of the chemical plume for Alternative A, as depicted by the cleanup concentration line is shown in Figure 4-1A for the shallow aquifer and in Figure 4-1B for the intermediate aquifer. Under this alternative, with no additional pumping, the plume migrates toward the west.in the shallow aquifer and toward the west-northwest in the intermediate aquifer. Figures 4-1A and 4-1B were prepared assuming a hydraulic conductivity of 200 feet/day. The rate of plume migration is directly proportional to the hydraulic conductivity. Thus, if the hydraulic conductivity were 100 ft/day instead of the 200 ft/day used, the plume would migrate half as fast. For a conservative cost estimate, the time required to reach the cleanup level was taken consistent with a hydraulic conductivity of 100 ft/day rather than 200 ft/day.

As the plume reaches the left side of the model in Figure 4-1A, the shallow aquifer merges with the intermediate aquifer as discussed in the RI. Thus, when the plume reaches the left side of the model, the shallow aquifer has reached the cleanup level. This takes 5 years as shown in Figure 4-1A. However, for a conservative cost estimate, we assumed a 10-year monitoring period for this alternative because the hydraulic conductivity could easily vary by a factor of 2.

The net present worth of the cost for implementing Alternative A is $1,525,000 at a discount rate of 3 percent, $1,387,000 at 5 percent, and $1,116,000 at 10 percent, as summarized in Table 4-3. The cost summary for Alternative A is presented in Table 4-4. There are no capital costs for this alternative because no additional pumping or treating is involved. Monitoring and reporting costs have been included at $14,000/month for 120 months. A period of 120 months was used for comparison purposes. As discussed earlier the computer simulations indicate the cleanup period is directly proportional to the hydraulic conductivity. The cleanup period is projected at 60 to 120 months. This analysis includes a cost of $4,000/month for 24 months for maintaining the existing treatment plant in an operational mode in the event that the concentrations of chemicals in the ground water increase and it is decided to restart the plant. No salvage value for the treatment plant is included in the analysis.

4.2.2 Alternative B

Alternative B consists of a continuation of the existing pumping and treating of ground water from the shallow aquifer only, on- and off-site. Currently, there are 15 on-site extraction wells and 5 off-site extraction wells in the shallow aquifer. The site manager adjusts the flowrate from each of these extraction wells to accommodate changes in the concentrations indicated by the monitoring data. This pumping and treating will continue until the monitoring data indicate that the chemical concentrations in the ground water in the shallow aquifer are less than the ground-water cleanup levels.

This alternative includes maintaining the treatment plant in a standby mode for two years, ready to be placed back in service if necessary. After two uninterrupted years with no concentrations above the cleanup levels (see Section 5-2), all or portions of the treatment plant may be dismantled and salvaged. At this point, some of the monitoring and extraction wells may be abandoned according to state and local requirements. Monitoring will continue in the 120-foot aquifer until two years after the chemical concentrations reach the ground-water cleanup levels. Then, the 120-foot aquifer monitoring wells may be abandoned. At this point, the remedial action will be complete. Sufficient wells will be retained to provide data for the 5-year review required by CERCLA Section 121(c).

For this alternative, the treatment plant will continue to operate with both the air stripper and the carbon beds as it is presently operating.

Computer simulations have been made for Alternative B, similar to Alternative A. The areas of the shallow and intermediate aquifers with concentrations above the cleanup levels in this alternative are depicted in Figure 4-2A and B. In contrast to Alternative A, Figure 4-2A shows that the extraction wells arrest the westward flow of the plume in the shallow aquifer. In fact, this figure shows the cleanup level contour closing around both the on-site and the offsite extraction well fields. Figure 4-2A shows that Alternative B cleans up the shallow aquifer in 2 years as opposed to 5 years for Alternative A (for a hydraulic conductivity of 200 ft/yr) as shown in Figure 4-1A. Thus, Alternative B is expected to achieve the cleanup levels in the shallow aquifer in about 40% of the time required by Alternative A.

The cleanup in the intermediate aquifer proceeds at the same rate for both Alternative A and Alternative B because there is no pumping from this aquifer in either alternatives. The effect of reducing the mass loading into the intermediate aquifer compared to Alternative A is small.

The net present worth of the cost for implementing Alternative B is $3,186,000 at a discount rate of 3 percent, $2,990,000 at 5 percent, and $2,588,000 at 10 percent, as summarized in Table 4-3. The cost summary for Alternative B is presented in Table 4-5. There are no additional capital costs for this alternative because no additional pumping or treating capacity is involved. For purposes of this cost comparison, monitoring and reporting costs have been included at $18,000/month for 33 months (while the treatment plant was assumed to be operating) and $14,000/month for 120 months. A period of 120 months was used for comparison purposes. As discussed earlier the computer simulations indicate the cleanup period is directly proportional to the hydraulic conductivity. The cleanup period is projected at 60 to 120 months. This analysis includes a cost of $35,200/month for 33 months for operating the existing treatment plant. No salvage value for the treatment plant is included in the analysis.

It is recognized that the results of computer models have limitations, and therefore, the best available predictions of ability and time to meet ARARs may not be accurate. Therefore, this remedial alternative would include evaluation of system operations and effectiveness on a semi-annual basis, based on monitoring data. In the event remedial goals cannot be achieved, the RAP/ROD may be amended accordingly by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

4.2.3 Alternative C

Alternative C was defined to pump and treat the affected ground water in the 120-foot aquifer as well as the ground water in the shallow aquifer. This alternative consists of installing and developing five new extraction wells in the 120-foot aquifer and starting to pump and treat ground water from this aquifer concurrently with the pumping from the shallow aquifer.

For Alternative C, the pumping and treating of ground water from the 20 existing extraction wells in the shallow aquifer will continue. The site manager will adjust the flow from each well based on the monitoring data. After the concentrations in the shallow aquifer decline to the ground-water cleanup levels, pumping from the shallow aquifer will be stopped, but monitoring in the shallow aquifer will continue for an additional two years.

In addition to this shallow aquifer remediation, Alternative C includes pumping and treating ground water from the 120-foot aquifer. The five new extraction wells in the 120-foot aquifer will be located in a line along the axis of the chemical plume. The actual locations will vary somewhat depending on the time that the wells are installed because the plume is continuing to migrate toward the northwest. Thus, the longer it takes to obtain the access permits and agency approvals and the longer the installation may be delayed due to planting cycles or weather, the farther to the northwest is the optimum location of the new extraction wells.

The pumping and treating of ground water from the 120-foot aquifer will be started as soon as the new wells can be installed and developed. The flowrates from both the 120-foot and the shallow aquifer will be adjusted by the site manager based on the monitoring data. For Alternative C, the combined flowrate will exceed 650 gpm, and the minimum flowrate from the new wells in the intermediate wells will be 400 gpm. Thus, the treatment plant will require modification and, because the flowrate exceeds 1,000 gpm, the NPDES permit will have to be modified. (For the purposes of this report, it has been assumed that a new air stripper with a capacity of 500 gpm will be installed, based on a comparison of costs with a new carbon adsorption system). This pumping and treating of ground water from the 120-foot aquifer will continue until the concentrations are below the ground-water cleanup levels.

Monitoring in all aquifers will continue for two years after this to assure that no concentrations above the cleanup levels occur. This alternative includes maintaining the treatment plant in a standby mode for two years, ready to be placed back in service if necessary. After two uninterrupted years with no concentrations above the cleanup levels (see Section 5-2), all or portions of the treatment plant may be dismantled and salvaged. At this point, some of the monitoring and extraction wells may be abandoned according to state and local requirements. Sufficient wells will be retained to provide data for the 5-year review required by CERCLA Section 121(c).

Results of the computer simulations for Alternative C are presented in Figures 4-3A and B for the shallow and intermediate aquifers, respectively. The cleanup in the shallow aquifer for Alternative C proceeds as it did for Alternative B, (Figure 4-2A) because the pumping is the same. However, as can be seen in Figure 4-3A, continuing pumping from both the onsite and offsite shallow aquifer wells results in developing a null point between the two extraction well fields where the gradient is relatively small. As shown in Figure 4-3A, the shallow aquifer is cleaned up in 2 years.

The cleanup of the intermediate aquifer is depicted in Figure 4-3B. This shows that cleanup is achieved in 1 1/2 years.

The net present worth of the cost for implementing Alternative C is $5,905,000 at a discount rate of 3 percent, $5,722,000 at 5 percent, and $5,308,000 at 10 percent, as summarized in Table 4-3. The cost summary for Alternative C is presented in Table 4-6. The capital costs for this alternative include the cost for a new air stripper and the cost for installing five new extraction wells and a new segment of pipeline. Monitoring and reporting costs have been included at $18,000/month for 33 months. This analysis includes a cost of $4,000/month for 24 months for maintaining the existing treatment plant in an operational mode in the event that the concentrations of chemicals in the ground water increase and it is decided to restart the plant beyond the planned operational period. No salvage value for the treatment plant is included in the analysis.

A primary objective of this remedial effort will be to establish a zone of capture for chemicals above the cleanup levels in the intermediate aquifer. Accordingly, once the new extraction wells are installed, they will be sampled for contaminants to determine the concentrations at the wells. If necessary, one or more additional wells will be installed farther downgradient and/or pumping rates adjusted to ensure that the capture zone intercepts any portion of the plume with contaminant concentrations above the cleanup level for any contaminant.

Once pumping has commenced, aquifer tests will be performed to verify the zone of capture for the wells. If necessary, another well may be installed further downgradient and pumping rates adjusted accordingly so that any portion of the plume containing concentrations above the cleanup levels for any contamination is intercepted.

It is recognized that the results of computer models have limitations, and therefore, the best available predictions of ability and time to meet ARARs may not be accurate. Therefore, this remedial alternative would include evaluation of system operations and effectiveness on a semi-annual basis, based on monitoring data. In the event remedial goals cannot be achieved, the RAP/ROD may be amended accordingly by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

4.2.4 Alternative D

Alternative D, like Alternative C, was defined to pump and treat the affected ground water in the 120-foot aquifer as well as the ground water in the shallow aquifer. This alternative consists of installing and developing five new extraction wells in the 120-foot aquifer and pumping and treating ground water from this aquifer concurrently with the pumping from the shallow aquifer. The minimum flowrate from the new wells installed in the intermediate aquifer is 400 gpm. Capture zone analyses were done for Alternative D for both the shallow and intermediate aquifers because this is the recommended alternative.

4.2.4.1 Zone of Capture, Shallow Aquifer

For Alternative D, the pumping and treating of ground water from some of the 20 existing extraction wells in the shallow aquifer will continue. The purpose of determining the zone of capture is to provide information supporting the development of a feasible and practical plan for remediation of the ground water in the shallow aquifer. Additionally, the analysis must show that the scenario is feasible, timely, cost effective, and technically acceptable. One of the standard methods for determining the zone of capture is to use the Theis non-equilibrium, equation developed in 1935 and determine the drawdown or that portion of the aquifer dewatered resulting from the pumping of wells. There are many methods for determining the drawdown in wells, and they range from mathematical calculations plotted on graph paper to plots on graphs developed for this purpose.

Since pumping has been going on for several years in the shallow aquifer and a shrinking of the plume has been shown in the field-collected data, no calculations are performed for the shallow aquifer. A comparison of the plume size to the measured potentiometric levels will be used for this analysis.

The following pumping rates apply to the wells pumping from the shallow aquifer for this analysis:

On-site Wells

Well IT-S7 - 70 gpm
Well IT-S8 - 10 gpm
Well IT-S11 - 25 gpm
Well IT-M1 - 155 gpm
Total - 260 gpm

Off-site Wells

Well IT-SE2 - 70 gpm
Well IT-SE3 - 35 gpm
Well IT-SE4 - 70 gpm
Well IT-SE5 - 60 gpm
Total - 235 gpm

These pumping rates will be reduced when the five new intermediate aquifer extraction wells are installed and become operational. The combined flowrate will not exceed 650 gpm.

The 4 wells located on site are located more or less in a northeast-southwest line along the property line of the facility. The off-site wells are located in an "L" shape in an area approximately 800 feet west of the facility (Figure 3-12). The configuration of wells on-site appears to be the optimum arrangement for the interception of any contaminant migrating from the facility. The configuration of the off-site wells is an attempt to intercept and also compress the plume as it moved from the facility.

Figure 4-4 shows the capture zone for the shallow aquifer. A comparison of the January 1988 and 1989 contours indicates that the drawdown from the shallow wells is adequate to intercept the plume. The plume has decreased the size and concentration levels in a reasonable time frame and it appears that the wells will continue to intercept the plume for the duration of their pumping.

The site manager will adjust the flow from each well based on the monitoring data. After the concentrations in the shallow aquifer decline to the ground-water cleanup levels, monitoring in the shallow aquifer will continue for an additional two years. Monitoring will continue under this alternative until the chemical concentrations in each of the wells decrease to below the ground-water cleanup levels. Then, monitoring will continue for an additional two years to assure that no unusual increases in the concentrations above the cleanup levels occur (see Section 5.2).

4.2.4.2 Zone of Capture, Intermediate Aquifer

In addition to this shallow aquifer remediation, Alternative D includes pumping and treating ground water from the 120-foot (intermediate) aquifer. The purpose of determining the zone of capture is to provide information supporting the development of a feasible and practical plan for remediation of the ground water in the 120-foot aquifer. Additionally, the calculations must show that the scenario is feasible, timely, cost effective, and technically acceptable. One of the standard methods for determining the zone of capture is to use the Theis non-equilibrium equation developed in 1935 and determine the drawdown or that portion of the aquifer dewatered resulting from the pumping of wells. There are many methods for determining the drawdown in wells and they range from mathematical calculations plotted on graph paper to plots on graphs developed for this purpose. The method to be used in this section will be a computer generated result and is described as follows.

The zone of capture is defined using the Prickett solution of the Theis non-equilibrium equation (Figure 4-5A). The program RESSQ was used to calculate flow patterns (Figures 4-5B and C). Appendix J of this report explains these models, the effectiveness, the limitations, and the assumptions required for their operation.

The following constants were used to determine drawdown.

Transmissivity - 74,800 gpd/ft or 10,000 ft^2/d
Storage Coefficient - 0.001
Pumping Rate - 650 gpm for Figures 4-5A and B
- 400 gpm for Figure 4-5C

The 5 wells are located in a line as shown in Figure 3-12, with wells IT-IE2 through 5 separated by about 300 feet and wells IT-IE1 and 2 separated by about 880 feet. This configuration of wells is the optimum arrangement as demonstrated in this document.

Figure 4-5A shows the capture zone for the 120-foot aquifer. Note that after 30 days of pumping the cone of depression (zone of capture) reaches beyond the January 1989 target cleanup area. This indicates that the drawdown is adequate to intercept the plume within a reasonable time frame and will continue to intercept the plume for the duration of the pumping.

The five new extraction wells in the 120-foot aquifer will have a minimum pumping rate of 400 gpm and will be located in a line along the axis of the chemical plume. The actual locations will vary somewhat depending on the time that the wells are installed because the plume is continuing to migrate toward the northwest. Thus, as in Alternative C, the longer it takes to obtain access permits and agency approvals and the longer the installation may be delayed due to planting cycles or weather, the farther to the northwest is the optimum location of the new extraction wells.

The pumping and treating of ground water from the the 120-foot aquifer will be started as soon as the new wells can be installed and developed. The flowrates from both the shallow aquifer and the 120-foot aquifer extraction wells will be adjusted by the site manager based on the monitoring data. However, the combined flowrate will be less than 650 gpm so the treatment plant will not require modification and new operating permits are not required. This pumping and treating of ground water from the 120-foot aquifer will continue until the chemical concentrations are below the ground-water cleanup levels. Then, pumping will be stopped, but monitoring in the 120-foot aquifer will continue for an additional two years. At this point, some of the monitoring and extraction wells may be abandoned according to state and local requirements. Sufficient wells will be retained to provide data for the 5-year review required by CERCLA section 121(c).

4.2.4.3 Computer Simulations

Results of the computer simulations for Alternative D are presented in Figures 4-6A and B for the shallow and intermediate aquifers, respectively. The pumping scenario described below is for modeling purposes only. For actual conditions, pumping rates will be based on the monitoring well design, and the results of aquifer testing and monitoring. Both shallow and intermediate aquifer wells can be pumped at the same time. However, the pumping rates for all intermediate aquifer wells combined will be a minimum of 400 gpm. The cleanup in the shallow aquifer proceeds as shown in Figure 4-6A. This figure shows that the plume migration in the shallow aquifer is initially arrested by the current pumping. To break the null point discussed in Alternative C, the on-site, shallow aquifer pumping has been simulated as being terminated in August 1989. Off-site, shallow aquifer pumping is continued at 200 gpm until October 1989 for this simulation. This allows the remaining shallow aquifer plume to migrate under the regional gradient toward the merging of the shallow and intermediate aquifers. Figure 4-6A shows that by February 1991 only an area about 800 feet long is covered with the target cleanup plume, and by February 1992 the shallow aquifer is practically all below the cleanup levels.

The cleanup of the intermediate aquifer is depicted in Figure 4-6B. This shows that cleanup is achieved under this simulation in 1 1/2 years. This alternative also avoids developing a null point between the shallow and intermediate aquifers by terminating the shallow aquifer pumping earlier than the intermediate aquifer pumping.

Two additional variations of Alternative D have been simulated. These are labeled as Alternative D' (650 gpm) and Alternative D' (400 gpm). The purposes of these additional simulations were to assess the effect of a delay in beginning pumping from the intermediate aquifer and the effect of pumping at a flowrate of only 400 gpm.

As discussed in Section 3, if there are delays in obtaining access agreements or agency approvals, it may not be possible to install the new extraction wells and new pipeline segment by the fall of 1989. If this occurs, the installation will have to be delayed until the spring of 1989 because the drill rigs and construction equipment may not be allowed to damage the fields and roads during the winter rainy season. Thus, a simulation was made with the intermediate aquifer pumping starting in April 1990. The results of this simulation (Figure 4-6C) show that the proposed well locations are not as effective as they are if the pumping is started in the fall of 1989. The wells should be relocated farther to the west, as discussed in Section 3.

The fourth simulation used the fall of 1989 as the start date of pumping from the intermediate aquifer. However, in contrast to the simulation depicted in Figure 4-6B where the pumping rate was 650 gpm, the pumping rate used for the simulation was only 400 gpm. The results of this simulation are summarized in Figure 4-6D. This figure shows that a pumping rate of 400 gpm is only minimally effective in containing the intermediate aquifer plume. Thus, for the recommended alternative a minimum pumping rate of 400 gpm is specified.

4.2.4.4 Summary of Costs

The net present worth of the cost for implementing Alternative D is $1,829,000 at a discount rate of 3 percent, $1,792,000 at 5 percent, and $1,708,000 at 10 percent, as summarized in Table 4-3. The cost summary for Alternative D is presented in Table 4-7. Capital costs for this alternative include the costs for installing the five new wells and a new segment of pipeline; there are no new capital costs for the treatment plant. Monitoring and reporting costs have been included at $18,000/month for 12 months and at $14,000/month for 24 months. This analysis includes a cost of $4,000/month for 24 months for maintaining the existing treatment plant in an operational mode in the event that the concentrations of chemicals in the ground water increase and it is decided to restart the plant. No salvage value for the treatment plant is included in the analysis.

4.2.4.5 Remedial Action Goals

A primary objective of this remedial effort will be to establish a zone of capture for chemicals above the cleanup levels in the intermediate aquifer. Accordingly, once the new extraction wells are installed, they will be sampled for contaminants to determine the concentrations at the wells. If necessary, one or more additional wells will be installed further downgradient and/or pumping rates adjusted to ensure that the capture zone intercepts any portion of the plume with contaminant concentrations above the cleanup level for any contaminant.

Once pumping has commenced, aquifer tests will be performed to verify the true zone of capture for the wells. If necessary, another well may be installed further downgradient and pumping rates adjusted accordingly so that any portion of the plume containing concentrations above the cleanup levels for any contamination is intercepted.

It is recognized that the results of computer models have limitations, and therefore, the best available predictions of ability and time to meet ARARs may not be accurate. Therefore, this remedial alternative would include evaluation of system operations and effectiveness on a semi-annual basis, based on monitoring data. In the event remedial goals cannot be achieved, the RAP/ROD may be amended accordingly by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

4.2.5 Alternative E

Alternative E, like Alternatives C and D, was defined to pump and treat the affected ground water in the 120-foot aquifer as well as the ground water in the shallow aquifer. This alternative consists of installing and developing two new extraction wells in the 120-foot aquifer and pumping and treating ground water from this aquifer concurrently with pumping from the shallow aquifer.

For Alternative E, the pumping and treating of ground water from some of the 20 existing extraction wells in the shallow aquifer will continue. The site manager will adjust the flow from each well based on the monitoring data. After the chemical concentrations in the shallow aquifer decline to the ground-water cleanup levels, monitoring in the shallow aquifer will continue for an additional two years.

In addition to this shallow remediation, Alternative E includes pumping and treating ground water from the 120-foot aquifer. The two new extraction wells in the 120-foot aquifer will be located in a line along the axis of the chemical plume. The actual locations will vary somewhat depending on the time that the wells are installed because the plume is continuing to migrate toward the northwest. Thus, the longer it takes to obtain access permits and agency approvals, and the longer the installation may be delayed due to planting cycles or weather, the farther to the northwest is the optimum location of the new extraction wells.

The pumping and treating of ground water from the 120-foot aquifer will be started as soon as the new wells can be installed and developed. The flowrates from both the shallow aquifer and the 120-foot aquifer extraction wells will be adjusted by the site manager based on the monitoring data. However, the combined flowrate will be less than 650 gpm, and the treatment plant will not require modification. This pumping and treating of ground water from the 120-foot aquifer will continue until the chemical concentrations are below the ground-water cleanup levels. Then pumping will be stopped and monitoring in the 120-foot aquifer will continue for an additional two years. If no concentrations above the cleanup levels occur (see Section 5-2), some of the monitoring and extraction wells in the 120-foot aquifer may be abandoned, and the treatment plant may be disassembled and salvaged. Sufficient wells will be retained to provide data for the 5-year review required by CERCLA Section 121(c).

Results of the computer simulations for Alternative E are presented in Figures 4-7A and B for the shallow and intermediate aquifers, respectively. The cleanup in the shallow aquifer proceeds as shown in Figure 4-7A. This figure shows that the plume migration is initially arrested by the current pumping. To break the null point discussed in Alternative C, the onsite pumping is terminated in 6 months. Off-site, shallow aquifer pumping is continued at 200 gpm for 9 months. This allows the remaining plume to migrate under the regional gradient toward the merging of the shallow and intermediate aquifers. Figure 4-7A shows that only an area about 1,000 feet long is covered with the target cleanup plume at that time, and by the Spring of 1992 the shallow aquifer is practically all below the cleanup level.

The cleanup of the intermediate aquifer is depicted in Figure 4-7B. This shows that cleanup is achieved in 5 years. This alternative also avoids developing a null point between the shallow and intermediate aquifers by terminating the shallow aquifer pumping earlier than the intermediate aquifer pumping.

The net present worth of the cost for implementing Alternative E is $3,444,000 at a discount rate of 3 percent, $3,311,000 at 5 percent, and $3,017,000 at 10 percent, as summarized in Table 4-3. The cost summary for Alternative E is presented in Table 4-8. Capital costs for this alternative include the costs for installing two new extraction wells and a new segment of pipeline; there are no capital costs for the treatment plant. Monitoring and reporting costs have been included at $18,000/month for 36 months and at $14,000/month for 12 months. A period of 120 months was used for comparison purposes. As discussed earlier the computer simulations indicate the cleanup period is directly proportional to the hydraulic conductivity. The cleanup period is projected at 60 to 120 months. This analysis includes a cost of $4,000/month for 24 months for maintaining the existing treatment plant in an operational mode in the event that the concentrations of chemicals in the ground water increase and it is decided to restart the plant. No salvage value for the treatment plant is included in the analysis.

A primary objective of this remedial effort will be to establish a zone of capture for chemicals above the cleanup levels in the intermediate aquifer. Accordingly, once the new extraction wells are installed, they will be sampled for contaminants to determine the concentrations at the wells. If necessary, one or more additional wells will be installed further downgradient and/or pumping rates adjusted to ensure that the capture zone intercepts any portion of the plume with contaminant concentrations above the cleanup level for any contaminant.

Once pumping has commenced, aquifer tests will be performed to verify the zone of capture for the wells. If necessary, another well may be installed further downgradient and pumping rates adjusted accordingly so that any portion of the plume containing concentrations above the cleanup levels for any contamination is intercepted.

It is recognized that the results of computer models have limitations, and therefore, the best available predictions of ability and time to meet ARARs may not be accurate. Therefore, this remedial alternative would include evaluation of system operations and effectiveness on a semi-annual basis, based on monitoring data. In the event remedial goals cannot be achieved, the RAP/ROD may be amended accordingly by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

4.3 DETAILED ANALYSIS

A detailed analysis has been performed on each alternative using the previously presented evaluation criteria. The primary remediation goal is the control of the migration and removal of contaminants in the ground water resulting from the operation of the Firestone facility in the Salinas Valley, California. This will be accomplished by determining the best pumping alternative that will provide the highest level of contaminants for treatment at the most cost-effective level.

This analysis includes an evaluation of each alternative by criteria and a comparison of the relative performance among alternatives. The effectiveness of the alternatives in meeting contaminant-specific, location-specific, and action-specific ARARs are discussed separately. The detailed analysis presented in this section is not intended to be complete and final, but is intended to present sufficient information about each alternative to allow a comparative evaluation.

4.3.1 Short-Term Effectiveness

The primary remedial response objective to be achieved by the remedial action is attainment of ground water quality at the cleanup levels for chemicals in the site ground water. Alternatives C and D would most likely achieve these objectives the earliest. There is only a marginal difference in time between the two alternatives. Alternative C and Alternate D well field layout in the intermediate aquifer appears to be well suited to the site geology. The limited number of wells installed under Alternative E may not provide an efficient field for capture of chemicals. Additionally, full utilization of the existing treatment plant after the shallow zone is fully remediated may not be achievable, pumping from only two wells in the intermediate zone, during the later stages of Alternative E. In any event, the time required to remediate under Alternative E would exceed that required for Alternatives C and D.

Alternative B does not provide active remediation of the intermediate zone. Alternative A provides no further active remediation. Implementation of either of these alternatives could contaminate downgradient aquifers. Remediation of the intermediate zone (Alternatives C, D, and E) is expected to remove contaminated ground water significantly and reduce the potential of significant contamination of the deeper aquifers.

The risk to the community is highest under the No-Action Alternative A. The potential for contaminant exposure is highest, if contaminants are allowed to migrate to the deeper aquifers. Passive remediation utilizing natural attenuation mechanisms and agricultural well use allows a greater potential for further contamination of wells. Alternative C may result in atmospheric discharges of contaminants from the new air stripper at levels approaching the current discharge criteria (potentially limiting operation or requiring further monitoring). Alternatives B, D, and E present the lowest risk to the community during remediation. Incremental differences between these alternatives may not be significant.

The risk to workers, although still small, will be greatest under Alternative C. Construction-related risk varies with level of improvements. Alternative C includes constructing a new air stripper and five new wells, Alternative D includes five new wells, Alternative E includes two new wells only. The increase in emissions under Alternative C would lead to an increased hypothetical risk to the worst-case worker exposure scenario. Alternatives A, B, and E have the lowest potential for worker risk.

Short-term environmental impacts are greatest under Alternative A followed by Alternative B due to the potential for further migration of the contaminant plume. The high flowrate of ground water withdrawal under Alternative C may have a minor impact on ground water recharge and lead to entrainment of relatively noncontaminated ground water. Alternatives D and E will have the least impacts on the environment during construction and implementation of the remedial alternative. Environmental disturbances due to construction activities under Alternatives C, D, and E correspond with their respective levels of construction.

Summary of Short-Term Effectiveness

Based on the above discussions, the alternatives with intermediate aquifer extraction are rated approximately equal. Alternative B is less short-term effective due primarily to lack of intermediate zone treatment, and Alternative A is least short-term effective due to total reliance on passive remediation techniques.

4.3.2 Long-Term Effectiveness and Permanence

The magnitude of residual risk is highest for Alternative A due to the higher potential for contamination of domestic and agricultural wells from reliance on natural mechanisms for remediation of the shallow and intermediate zones. Shallow aquifer active remediation under Alternative B produces long-term residual risk less than Alternative A, but greater than Alternatives C, D, and E. Alternatives C, D, and E all remediate the intermediate zone, although Alternatives C and D are most likely to remove more contaminants than Alternative E due to capture efficiency of the larger well field.

Monitoring and relying on natural mechanisms for remediation of shallow and intermediate zone aquifers in Alternative A and the intermediate zone aquifers in Alternative B are deemed marginal to control further spread of contamination. Long-term monitoring and maintenance of plant for restart would be required. Contamination could spread to a point where remediation was no longer feasible. Installing a new air stripper as presented in Alternative C could require significant downtime to allow for construction and debugging. The existing system has been proven and is currently operating smoothly and reliably. Alternatives D and E are the most reliable alternatives.

The plume maps for the deep aquifer (Figures 3.7 and 3.8) show that the plume is lenticular in shape and, although 26 deep aquifer monitoring wells were installed, only a limited number of these wells detected any chemicals. A model simulation of the deep aquifer was studied to assess the effectiveness of pumping from the agricultural wells in remediating the deep aquifer. The results indicate that the agricultural wells strongly influence the direction of ground-water flow and additional extraction wells would have difficulty matching the withdrawal rate and influence. Therefore, data from the Harden 12 AG well was used to determine the trends of concentrations of chemicals in the deep aquifer. Figure 4.8 shows the downward trend of 1,1-DCE in the Harden 12 AG well over the past 3 years. Although two deep aquifer monitoring wells, ITM17A and ITM18A, have 1,1-DCE levels above drinking water standards, a downward trend is expected, similar to the Harden 12 AG well. Because agricultural use of the water has generally decreased the concentrations to a relatively low level of chemicals in the aquifer or has prevented large increases of concentrations of chemicals, and, this can be expected to continue in the future, no alternatives requiring additional extraction wells are planned for the deep zone.

Summary of Long-Term Effectiveness and Permanence

Based on the potential inadequacy of natural mechanisms to fully or partially remediate shallow or intermediate aquifers as required for implementation of Alternatives A and B, capture efficiencies of various intermediate zone remediation alternatives, and proven efficiency of the existing plant, the alternatives are ranked from the most to least long-term effective and permanent as follows: D, C, E, B, A.

4.3.3 Reduction of Toxicity, Mobility, and Volume

Under the No-Action alternative, no active treatment process is employed. Treatment processes for all the other alternatives utilize air stripping and carbon adsorption technology as appropriate treatment processes, as discussed in Section 2.0. Alternative C would necessitate increased treatment plant capacity most likely in the form of an additional air stripper. The current air stripper and carbon adsorption system are flow limited at 180 gpm and 500 gpm, respectively.

The existing combined treatment system meets NPDES and MBUAPCD air permit requirements. Permit modifications would be required for Alternative C.

Alternative C has the highest potential to treat the greatest amount of ground water, although the removal efficiencies may suffer due to dilution of contaminants by entrainment of noncontaminated ground water. Alternative D is expected to remove only slightly less contaminants than Alternative C, but in doing so, will extract a much lesser volume of water. Of the intermediate zone extraction methods, Alternative E will potentially extract the least amount of contaminants due to the reduction in contaminant capture efficiency caused by using only two wells in the intermediate aquifer. Alternative B will not address active remediation of contaminants in the intermediate aquifer. Alternative A will not address active remediation of the shallow or the intermediate aquifers.

The treatment processes involved are primarily irreversible removal processes where little destruction takes place directly. Contaminants adsorbed by the carbon unit are later removed from the carbon by a recycling firm. The spent carbon may be considered a treatment residual. Volatiles removed from the air stripper are emitted to the air and may undergo photochemical reactions in the atmosphere. Alternatives D and E would generate more carbon than Alternative C due to the reliance on the carbon units for a greater percentage of waste stream treatment and longer treatment period. Similarly, greater local air emissions would be encountered under Alternative C.

Summary of Reduction of Toxicity, Mobility, and Volume

Alternative C may provide slightly greater removal of contaminants from the ground water, although local discharges to surface water and air may be higher. Alternative D appears to provide the best match of removal, due to the fact that highly contaminated areas will be preferentially treated first. Capture efficiency may suffer for Alternative E due to too few wells, whereas Alternatives A and B do not thoroughly address each of the chemical plumes.

4.3.4 Implementability

4.3.4.1 Technical Feasibility

Alternatives A and B require no new construction, and can be implemented immediately. Alternatives C, D, and E require installation of new off-site extraction wells. In addition, Alternative C would require expansion of the existing treatment plant. Construction of new off-site wells would require permits and easements from property owners.

Installation of new wells would have to be done during the dry season. Previous experience has shown damage to fields may be caused if drilling is attempted during wet weather. This restriction may cause some unscheduled delays.

The least reliable alternative is A. Natural degradation or dilution of the plume is dependent on many changing factors. Contaminant concentrations within the plume may decrease slower than predicted extending the remediation time even further. The plume during that time may migrate farther into the aquifers. However, should this trend be observed, counteractive measures such as resuming ground water extraction could be implemented.

The water-treatment technologies of carbon treatment and air stripping used in Alternatives B, C, D, and E are well demonstrated and very efficient. Ground-water extraction has been demonstrated as an effective way to control the movement of the contamination plume.

The technologies recommended by the proposed alternatives would be expected to develop schedule delay as a result of technical failure. However, Alternative A is the most likely alternative to be slower than expected. Alternatives C and D would take longer to implement due to new well construction but this delay is accounted for in the schedule.

None of the alternatives would hinder or prevent the taking of additional remedial action. The only delays that may be incurred are obtaining any required permits and the time to implement additional strategies.

Under interim remediation status, numerous monitoring wells were installed at the site and existing water wells identified near the vicinity. The site geology is complex. However, it is not anticipated that any of the alternatives, if implemented, would require additional monitoring wells to be installed. There are monitoring wells between the contamination plume and existing downgradient drinking water wells.

Summary of Implementability

Alternatives C and D are most likely to be technically successful and meet predicted schedule dates. Alternative A is least likely to decrease contamination levels to desired levels by the scheduled dates.

4.3.4.2 Administrative Feasibility

Currently, the air permit for the air stripper limits flow to 180 gpm and various contaminant-specific emissions. It is anticipated that flowrates may be modified, if a new air stripper were installed, but total facility emission increases would not be allowed to increase. Increases in emission upon installation of an air stripper per Alternative C may approach or exceed emission standards or the 75 percent threshold requiring additional monitoring.

The NPDES permit currently limits discharges to the Salinas River to 1,000 gpm. High flowrate limits may be exceeded under Alternative C. Additionally, some debugging may be needed upon installation of the new air stripper, with potential upset conditions which may cause additional monitoring. Copies of the air permit and NPDES permit are found in Appendix A.

Alternatives C, D, and E all require obtaining leases, easements, or purchasing property to allow for installation of additional extraction wells in the intermediate aquifer. Obtaining access and necessary permits would be easier under Alternative E due to the fact that only two wells (compared to five wells for Alternatives D and E) would be required.

Summary of Administrative Feasibility

Alternative C would be the most administratively difficult to achieve due to potential needs for air permit and/or NPDES modifications. Alternatives C and D would require more intermediate zone well field development than Alternative E and much less than Alternatives A and B, which require no new well fields or treatment systems.

4.3.4.3 Availability of Services and Materials

All the technologies required by Alternatives A through E are available, demonstrated, and do not require licensing. The treatment methods of carbon adsorption and air stripping have been well demonstrated by the operation of the existing treatment plant.

Ground-water extraction is a widely used method for aquifer cleanup. Alternative A (No-Action Alternative) is the option with the highest degree of technical risk. Although natural degradation and dilution will occur, the specific rate at which this occurs is dependent on each site's characteristics. The effectiveness of a controlled ground-water extraction plan can be predicted with greater certainty over simple, natural degradation and dilution processes.

None of the technologies used by Alternatives A to E would require further development. Predictive modeling will continue throughout the progress of the cleanup to verify previous assumptions and assist in making any adjustments to improve performance. There is no limit to the scale which the technologies in Alternatives B through E could be implemented. The existing treatment plant is limited to a treatment capacity of 650 gpm. Alternative C would require installation of additional treatment capacity. This would delay implementation due to the time required for design, procurement, delivery, and installation of the equipment.

Alternatives C, D, and E require installation of new wells. This will result in a certain delay time while permits and releases from landowners could be obtained. Wells must be installed during the dry season. Damage to fields may occur if installation is performed during wet weather. There is no reason to expect qualified drilling contractors would be unavailable. Implementation of Alternatives C, D, and E would also be delayed while design, services, well casing, pumps, utilities, and pipe are procured and installed.

Alternatives B, C, D, and E would require operation of the carbon treatment unit. It is estimated that single-bed carbon change outs will be required about every three months for the existing unit. This change out period will lengthen as remediation continues. There is no reason to expect a shortage of carbon availability, or contractor services to remove and dispose of spent carbon.

Summary of Availability of Services and Materials

Alternative A would be the simplest alternative to implement, requiring no services or materials other than monitoring. The monitoring period is longer than for the other alternatives; however, the operating cost is lowest. Alternative C has the highest risk of disruption due to lack of services. However, based on historical operating data, this risk is very low.

4.3.5 Cost

This section summarizes short- and long-term costs associated with the implementation of Alternatives A through E.

The estimates were prepared based on current operational cost data for the existing treatment plant, quotes obtained from vendors, and historical cost data extrapolated to current day value. The accuracy of the estimate is +35 percent to -20 percent. No inflationary rate factors are assumed in the cost analysis. No contingencies are included because the costs are well established from current operations. There should be no significant scope changes once an alternative is selected for implementation.

Any costs associated with the remediation after the end dates stated in the cost summary tables are not included in the analysis. These costs may include legal fees, mandatory site improvements, demolition of the treatment plant, removing or closure of wells, and any long-term site monitoring (SARA Section 121 (c)). No salvage value was awarded for the existing interim remediation equipment and no capital cost is incurred by alternatives that make use of existing equipment.

Table 4-3 summarizes the detailed cost analysis of Alternatives A through E. As expected, Alternative A (no action) is the least expensive to implement. However, it does have the highest risk for not achieving the desired cleanup levels within the scheduled time period. Alternative A has the highest potential for an overrun of budget due to an extended schedule but is least likely to overrun due to unforeseen inflation or economic changes.

Alternative B does not require any additional construction. However, Alternative B ends up being more expensive to implement due to the long duration, monitoring, and operating costs.

Alternative C has the highest cost of all the alternatives due to installation of new wells, and the requirements to expand the treatment plant. Economically, Alternative C has no advantage over Alternative D which is a similar remedial action plan but does not require expansion of the treatment plant. Alternative C is also predicted to require longer to implement than Alternative D due to modification of permits.

Alternative E is higher in cost than Alternative D due to the predicted longer duration required for completion and associated monitoring expense.

Potential Future Cost

SARA requires an evaluation of the potential for future remediation. Alternative A has the highest potential for requiring additional remedial measures. Alternatives C and D have the least potential for requiring additional remediation.

The greatest probable additional measures for Alternatives C and D which may be required is a longer pumping duration than estimated. Alternatives A, B, and E are slow and have a higher potential to be less effective. The most probable additional measures necessary would be to implement the remedial strategy of Alternative D. However, the greatest potential future cost associated with options A, B, and E would be caused by the extended time for cleanup. This delay may allow contamination to spread to deeper aquifers and expand the required cleanup efforts.

Summary of Cost

Alternative A (the no action alternative) would be the most economical option to implement but carries the highest degree of technical risk. Alternative D is the most economical of the action alternatives. Alternative D costs only slightly more than Alternative A and achieves the desired objectives in about one-third the time of Alternative A with lower technical risk.

4.3.6 Compliance with ARARs

A summary of examination of alternatives versus potentially applicable or relevant and appropriate requirements is presented in Table 4-1. Alternative A may not meet ARARs for either the shallow or intermediate aquifers, and alternative B may not meet ARARs for the intermediate aquifer. In both cases, the alternatives do not involve remedial action, and an indeterminate time period would be required for reaching cleanup levels. Reliance on passive, natural attenuation mechanisms for attainment of cleanup levels for these aquifers is required. Alternative C will need to obtain modifications of both the NPDES and MBUAPCD permits to meet ARARs.

Most of the ARARs and other guidance criteria to be considered are so specific for this site and actually define numerical remediation goals for chemicals of concern. Agency experience has shown that remediation goals may not be technically feasible to achieve in the modeled timeframes. The remedial alternative(s) include evaluation of system operations and effectiveness at periodic intervals. In the event remedial goals cannot be achieved, the RAP/ROD may be amended by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

4.3.7 Overall Protection of Human Health and the Environment

The potential risk to human health and the environment is highest under the No-Action Alternative A, followed by Alternative B, the remediate shallow aquifer only alternative. Both these alternatives present risk of contaminating the deep aquifers utilized for irrigation and drinking water purposes by relying on only natural mechanisms and irrigation practices for dispersion of contaminants.

Under Alternative C, the amount of contaminant capture is expected to be high, but mass balance releases to the environment may be increased in terms of quantity and rate. The entrainment of lesser contaminated waters into the treatment system may result in lower percent contaminant removal.

Alternative D appears to present the best match of protection in all media. Ground water will be selectively withdrawn to remove the most contaminated water sources first and affect maximum percent removal. Alternative E appears to be limited by the number of wells installed into the intermediate zone and may not adequately capture contaminants migrating to the deeper aquifers, and hence, be less protective than Alternatives C and D.

Summary of Overall Protection

Alternative D provides the best compromise between allowable air emissions, contaminant capture, treatment efficiency, and respondent protection of health and the environment. Alternative C may extract the greatest amounts of contaminants, but removal from the treatment stream and high air emission levels in reference to the air permits may occur. Alternative E may not adequately capture contaminants migrating to the deeper aquifers, Alternatives A and B most likely will not protect the deeper aquifers from contamination and potential human health and environmental risk.

4.3.8 State Acceptance

The state concurs with the remedy proposed.

4.3.9 Community Acceptance

There is no community opposition to the proposed remedy. All comments received have been addressed in the "Response Summary" prepared by the California Department of Health Services (Section 6 of this report).

4.4 SUMMARY OF DETAILED ANALYSIS

Table 4-2 provides a comparative summary of detailed analysis of the developed remediation alternatives. Synoptic summary for each criteria is provided in Section 4.3. Alternatives A and B do not adequately respond to the ground-water contamination problem and rely on passive mechanisms to assure ground-water remediation. Both Alternatives A and B have a high probability of introducing additional contaminants to the deep aquifer. Alternatives A and B are potentially low cost and easily implementable. The uncertainties in the effectiveness of these alternatives, ability to reduce risks due to further ground-water migration/degradation, and compliance with ARAR's render these alternatives unattractive.

Alternatives C, D, and E include installation of ground-water extraction wells into the intermediate aquifer for remediation of contaminated ground water. Alternatives C and D include installation of five wells into the intermediate zone; Alternative E includes installation of two wells only. As such, Alternatives C and D are expected to allow greater contaminant capture than Alternative E.

Although the treatment plant is upgraded under Alternative C, modeling has shown that high flowrates envisioned under this alternative may entrain large quantities of uncontaminated ground water. Alternative C may also require modification of NPDES and MBUAPCD air permits. Significant delays in installing the new air stripper under Alternative C may occur. Alternative D appears to be the alternative best matched to the site conditions, as supported by this detailed analysis.

5.0 RECOMMENDED REMEDIAL ACTION

5.1 SUMMARY OF REMEDIAL ACTION

Alternative D is the recommended remedial action alternative, based on the detailed analysis presented in this FS/RAP (Section 4.0). This alternative is summarized as follows:

- Installation and development of five (5) new extraction wells in the 120-foot aquifer.
- Disposal Alternative S, which is discharge of treated ground-water to the Salinas River.
- A new, approximately 1-mile-long pipeline segment is needed to connect the new extraction wells to the treatment plant.
- Treatment consisting of combined carbon adsorption and air stripping with the existing treatment plant.
- Pumping and treating ground-water from the 120-foot aquifer concurrently with the pumping from the shallow aquifer.
- Combined flowrate maintained at or below the capacity of the existing treatment plant of 650 gpm; the wells will not be pumped at their maximum flowrates.
- Minimum flowrate of 400 gpm from the intermediate aquifer.
- Pump testing of each new extraction well.
- Well field configuration in the intermediate aquifer appears to be well suited to the site geology.
- Effective short-term, with low impact on the environment during construction and implementation.
- Monitoring to continue in the shallow and intermediate aquifers until the concentrations have remained below the ground-water cleanup levels for two uninterrupted years.

5.2 ANALYSIS OF GROUND WATER SAMPLES

Ground water samples from monitoring, extraction, and agricultural wells are to be compared with established cleanup levels for each of the ten chemical compounds found at the site. Once the remedial pumping process has reduced all concentrations below cleanup levels, it is planned that the treatment system will be shut down and placed on standby. Monitoring will continue for two years, at a frequency to be determined in consultation with the regulatory agencies.

If a sample from a well that had previously been below the cleanup levels for any compound shows an increase to a value that exceeds that cleanup level, immediate well resampling will take place. A group of four replicate samples (not a four-way split) will be taken. Statistical analysis of the results will then be used to decide if the initial exceedance was statistically significant. The statistical confidence level to be used is 99 percent, with a 1 percent chance of a false negative, that the mean of the four replicates exceeds the cleanup level. A positive result is a finding from the statistical analysis that the observed exceedance of a cleanup level is statistically significant. Subject to revision and final determinations during the detailed design of the selected remedial action system, Student's "t" test will be used in the statistical analysis. Other approaches to be considered during final design include control chart methods, tolerance intervals, and prediction intervals. These are all accepted EPA methods for analysis of ground water data at RCRA sites.

Under this procedure, a positive result (i.e., a conclusion that the ground water concentration has risen above the cleanup level) would mean that the treatment plant would be reactivated, and wells would be sampled more frequently. The increased sampling frequency would continue until three consecutive period samples show concentrations below cleanup levels for all contaminants.

5.3 DEEP AQUIFER CONTINGENCY PLAN

It is expected that pumping in the intermediate aquifer will intercept the plume of contaminants from the site and that pumping in the deep aquifer will not be necessary. Levels of contaminants in the deep aquifer, which are (with few excursions) below the cleanup levels, are expected to decrease. However, there is the possibility that the cleanup system will not be as effective as expected, and that more contamination will reach the deep aquifer. The following is a contingency for this situation.

- The deep aquifer will be monitored on a quarterly basis, or as determined by the regulatory agencies. This will include analyses for all of the ten standard contaminants which have been found at the site. Cleanup levels have been established for these chemicals in this FS/RAP. Deep monitoring wells and agricultural wells will be monitored.
- Monitoring information will be used to evaluate the effectiveness of the pumping from the intermediate aquifer. If deep aquifer wells show a rise in concentrations, adjustments will be made, if possible, to the intermediate pumping system to halt the spread of contaminants to the deep zone.
- If the concentration of any contaminant in any deep well is found and confirmed to be above the cleanup levels established by this FS/RAP, the frequency of sampling for that well and the immediately surrounding wells will be increased to monthly. This frequency may be adjusted by the regulatory agencies. Sampling will continue on a monthly (or as-specified) basis for any such well until three consecutive periodic samples show concentrations below cleanup levels for all contaminants. Sampling frequency will then revert to a quarterly basis. As remediation nears completion, Firestone may petition DHS to further reduce the sampling frequency of such wells.
- If the concentration for any contaminant in a deep well remains above the cleanup level for more than one year, starting from the time the intermediate aquifer pumping begins, or if any concentration is found at any time which exceeds ten times the cleanup level, then:

  1) Firestone will provide, for any domestic or drinking water well with concentrations above cleanup levels, a wellhead treatment system, bottled water, or other interim means of effectively protecting public health which is approved by the regulatory agencies.

  2) For agricultural wells with concentrations above cleanup levels, Firestone will implement crop uptake testing and report the results to the regulatory agencies, who will then determine if further action is necessary.

  3) Firestone will submit to DHS, within ninety days and in accordance with the requirements of the involved agencies, a plan for remediating the deep aquifer.

Firestone will provide the wellhead treatment, bottled water, or other approved protection on a shorter time frame than that outlined above if the regulatory agencies determine, due to changing or unforeseen conditions, that there is an imminent threat to public health or the environment from deep aquifer contamination.

- If the concentration for any contaminant in a deep well remains above the cleanup level for more than eighteen months, or above ten times the cleanup level for more than three months, starting from the time that the intermediate zone pumping begins, then Firestone will implement the modified remedy according to the plan mentioned in item 3 above, as approved by the regulatory agencies. The public will be fully informed of any changes to the treatment system at the time of implementation. If any changes require a full RAP/ROD amendment, then the public will be fully involved as required by law before any such plan is implemented.

- If data from deep aquifer monitoring wells indicate that the downgradient extent of contamination in the deep aquifer is no longer known, then Firestone will monitor wells located further downgradient until the extent of the plume is again known. It is possible that there are other local sources of chemicals in the deep aquifer, particularly at the northwesterly end of the plume.

STATE OF CALIFORNIA—HEALTH AND WELFARE AGENCY
GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF HEALTH SERVICES
TOXIC SUBSTANCES CONTROL DIVISION
151 BERKELEY WAY, ANNEX 7
RKELEY, CA 94704

6.0 RESPONSIVENESS SUMMARY

FORMER FIRESTONE TIRE AND RUBBER SITE

Analysis of Public Comments Received on Draft RAP

August 14, 1989

I. Introduction

On July 13, 1989, the California Department of Health Services held a public meeting on the proposed remedial action plan for the former Firestone Tire and Rubber site, located in Salinas, Monterey County, California. The purpose of the meeting was to provide the public with information regarding the remedial action plan and to solicit public comments on the adequacy of the plan. In addition, comments on the remedial action plan were submitted to the Department during the public comment period which extended from June 27, 1989 to July 26, 1989.

The verbal and written comments which were received during the public meeting and comment period have been compiled according to the agency, individual or meeting. The purpose of this document is to present a written response by the Department to these comments.

A copy of the transcript of the public meeting and all the written comments received are available for review at:

Toxic Substances Control
Division
Region 2
5850 Shellmound, Suite 100
Emeryville, CA 94608
By Appointment Only
(415) 540-3401

John Steinbeck Library
110 West San Luis Street
Salinas, Ca 93901

II. Comments and Responses

The verbal and written comments which were received have been compiled and categorized by the following agencies, individuals or meetings:

A. Environmental Protection Agency
B. Public Water Supply Branch
C. Office of Planning and Research
D. Roy W. Fowler, Jr.
E. July 13, 1989 Public Meeting

RESPONSE SUMMARY

A. DHS RESPONSE TO EPA ADDENDUM ON FEASIBILITY STUDY/REMEDIAL ACTION PLAN FOR FIRESTONE, SALINAS

Note: Underlined text indicates language proposed by EPA.

1a. EPA Comment:
Page 3-4, Section 3-2, Paragraph 2: "above the drinking water action level." What action level? For which compound? This should be revised to reference the cleanup levels. If DCE is referred to, a rationale as to why it is a valid indicator parameter should be provided in the FS.

DHS Response:
DHS is in agreement with EPA that this statement needs to be clarified. The phrase "drinking water action level" will be changed to state that the plume maps show areas above the cleanup levels shown on page 2-6.

1,1-DCE is referred to in section 2.2 and on page 3-4. Rational for using 1,1,1-TCA and 1,1-DCE concentrations as indicator chemicals has been expanded. This includes referencing earlier observations that showed a decrease in other chemical concentrations as the concentration of DCE declined.

1b. EPA Comment:
Page 3-17 implies that No-action cleans up the aquifer. This implication should be removed. No-action would imply an escaping groundwater plume at concentrations above the action levels. While it is possible that after a long period of time concentrations would reach action levels by dispersion, it is not within common parlants to refer to dispersion and dilution as "cleanup".

DHS Response:
In order to clarify any misunderstanding caused by this paragraph, the following statement (which is also found in section 4.2.1) is included:

Alternative A, the No-action alternative, is required by regulatory guidelines and is considered as a baseline alternative.

2. EPA Comment:
Page 4-9, 4-10 for Alternative A state or imply that the alternative "cleans up" the aquifer. This language should be removed or qualified clearly (see comment [1b]).

DHS Response:
DHS does not believe that any implication is made that would suggest that Alternative A is a feasible alternative; however, the following language is added to clarify the definition of "cleanup":

This discussion under Alternative A is not meant to imply that No-action will cleanup the aquifer, rather that after some time, the observed concentrations of chemicals in the aquifer will decrease to below the groundwater clean up levels due to natural attenuation, degradation and diffusion.

3. EPA Comment:
Page 4-3, Paragraph 2: "Although the proposed NCP rule revisions at 53 FR 51394 has not been promulgated and the March 1988 RI/FS guidance has only been issued as a draft document, these documents provide ~~relevant and appropriate guidance~~ information on..." The stricken language is inappropriate given the parallel it invokes.

DHS Response:
DHS feels that the language may be mistaken to mean ARARs and therefore concurs with EPA's change.

4. EPA Comment:
Page 4-4, Paragraph (b). Add as last sentence: Compliance with ARARs is a threshold requirement. All alternatives remaining in the final analysis shall meet ARARs or have an approved ARAR waiver. It was not clear from the report that Firestone understands that meeting ARARs is not an optional exercise (although it is stated fairly clearly in Paragraph 1, page 4-8). By statute, ARARs must be met and alternatives which do not meet ARARs cannot be retained for analysis.

DHS Response:
While the last paragraph on page 4.7 states that alternatives that do not comply with ARARs will not meet statutory requirements for selection of remedy in the ROD, EPA's suggested language is added to page 4-4, paragraph (B). With the following change: "...have approved ARAR waivers" to "...obtain ARAR waivers".

5. EPA Comment:
Page 4-8, Section 4.2.1, Sentence 3. ~~Strictly speaking, there can be no "No-action" alternative at the Firestone Salinas site because there have been interim remedial measures undertaken since February 1986. Therefore, this alternative is in reality a "no continued remediation" alternative.~~ The "no-action" alternative is defined as being the current site conditions, absent the ongoing

remedial measures. The ongoing remedial measures consist of pumping and treating the groundwater with carbon adsorption and air stripping, and discharging the treated water to the Salinas River. Continued groundwater monitoring is not considered a remedial measure.

DHS Response:
The text has been changed to reflect EPA's concerns with the exception of the last sentence. DHS feels that this statement would be redundant given the fact that it has already been stated that Alternative A is not considered a remedial measure and a definition of cleanup has been provided.

6. EPA Comment:
Page 4-10, Section 4.2.2, paragraph 2: "...That no ~~unusual~~ ((see below)) increases occur in the concentrations of chemicals in the ground water. After two years of monitoring with no ~~unusual~~ ((see below)) increase in concentrations, all or portions..." The word "unusual is undefined and unclear. What is an "unusual" increase? Is "unusual" based on statistical significance? What numerical criteria shall be used to define significance? These should be added. Also, it is not clear from this discussion whether the two years will start over if there is a significant increase.

This same comment applies to the word "unusual" on Pages 4-12, 4-13, 4-18 and 4-20.

Connected to this issue is the fact that CERCLA Section 121(c), 42 U.S.C. 9621(c), requires that there be a review of hazardous waste cleanups, where hazardous substances remain on-site, at least every five years to ensure that the remedy remains protective of human health and the environment. The five years are counted from initiation of the remedy. If the remedy does not remain protective, EPA is instructed to use its cleanup authorities once again to address the problem.

Thus, Firestone could technically dismantle its treatment plant after two years with concentrations below cleanup levels. It would merely be necessary to maintain enough monitoring wells to review the cleanup effectiveness after five years. However, if levels increased for any reason, Firestone would be taking a great risk that an EPA CERCLA Section 106 Order would be issued requiring them to reassemble the treatment plant. As is clear to Agencies now, there are many instances where pump-and-treat systems are shut down and the resulting change in equilibrium causes a desorption of contaminants and an attendant rise in contaminant concentrations.

In order to minimize Firestone's risk as well as protect public health, EPA therefore recommends that two conditions be met before the plant is dismantled: two years of monitoring, with treatment operating, in which no well show levels above the cleanup criteria; and two years of monitoring with the pumps shut off entirely, in which contaminant levels do not rise above cleanup levels for any contaminant. A review of the effectiveness can then be made at the five-year point, and also at the end of the process, if the end comes at a time later than five years from initiation of the remedial action.

In order to address the vagueness of "unusual", and the five-year review issue, the referred wording to be added under each remedial alternative (except A) is as follows:

The shallow and intermediate aquifer extraction system (including extraction wells) shall not be abandoned until there has been:

1) with treatment operating, an uninterrupted two year period with no statistically-significant increase in concentrations for any chemical, nor any concentration above the cleanup levels established by this RAP;

2) with treatment shut down completely, an uninterrupted two year period with no concentration for any chemical above the cleanup levels established by this RAP.

The above two conditions shall apply over the entire aquifer system as a whole; not for one aquifer or the other separately.

Effectiveness reviews shall be performed by DHS and/or EPA after five full years from the initiation of the cleanup action, and again before the dismantling of the extraction system, if dismantling occurs after five years of initiation of the cleanup action.

As cleanup progresses, certain monitoring wells may be properly abandoned by Firestone. such abandonments shall require the prior approval of DHS and/or EPA in writing. After the extraction system is dismantled, certain monitoring wells shall remain available for sampling; Firestone shall apply to DHS and/or EPA at the time of dismantling to identify the wells which are to remain available.

A numerical criterion for "statistical significance" should be included.

DHS Response:

The term "unusual" has been deleted from the text. In its place, the text under each alternative states that Firestone is currently required to monitor the intermediate and shallow aquifers and will continue to do so in order to verify that no concentrations of chemicals exceed their cleanup levels as established by this RAP. If any chemical in any monitoring well sample is detected above its cleanup level, and the analysis is confirmed, the treatment plant will be started up again.

The monitoring period for groundwater will continue for 5 years from the start of the initiation of the final remedy or for a two year period after reaching cleanup levels, whichever occurs later. Chemical concentrations must remain below cleanup levels for an uninterrupted two year period or the two year monitoring period will begin again.

7. EPA Comment:
It is indicated on Page 4-18 that the shallow aquifer extraction wells will be shut down as early as August 1989. The wording of this alternative should be expanded to make it clear that remedial design will determine the pumping rates used from all the wells. While it should still be noted that the wells may be shut down, it is still possible that the wells will be pumped for some time. for example: Shallow wells = 100 gpm, Intermediate wells = 550 gpm, is possible.

DHS Response:
The following wording will be added after the first sentence of section 4.2.4.3:

The pumping scenario described below is for modeling purposes only. For actual conditions, pumping rates will be based on the monitoring well design and the results of aquifer testing and monitoring. Both shallow and intermediate aquifer wells can be pumped at the same time. However, the pumping rates for all intermediate aquifer wells combined will have a minimum of 400 gpm.

8. EPA Comment:
The "Compliance With ARARs" section has several problems. The greatest of these is that it is not clear from the report that the list of ARARs in the Tables will actually be complied with under the RAP. Also of concern is that ARARs are referenced summarily as "ARARs" rather than specifically. Rather that (sic) explain each problem in detail, we have provided our recommended text changes to solve these problems in as expeditious a manner as possible. The text here is from Section 4.3.6. Stricken text is shown ~~stricken~~. Additions are shown in italics (for purposes of

this summary, they are shown underlined). Comments in text are in double brackets (( )). This issue is critical.

"A summary of alternatives versus potentially applicable or relevant and appropriate requirements is presented in Table 4-1. Alternative A may not meet ~~ARARs~~ ((give specific ARARs it may not meet and why)) for either the shallow or intermediate aquifers. Alternative B may not ((why not?)) meet ~~ARARs~~ ((give specific ARARs)) for the intermediate aquifer. Reliance on passive, natural attenuation mechanisms for attainment of cleanup levels for these aquifers will occur. ~~Under~~ Alternative C will meet ARARs if permit modifications of both NPDES and MBUAPCD permits ~~to operate will be required~~ are obtained.

"~~At this point in the remedial process, definitive statements such as "this alternative does meet requirements" or "this alternative does not meet requirements" often cannot be made.~~ Most of the ARARs and other guidance criteria to be considered are ~~so~~ specific for this site and actually define numerical remediation goals for chemicals of concern. Agency experience has shown that remediation goals may not be technically feasible to achieve in the modeled timeframes. The remedial alternative(s) include evaluation of system operations and effectiveness at periodic intervals. Should the ability to obtain remediation goals become doubtful, the RAP will be amended accordingly and/or the appropriate ARAR waiver invoked. Any such RAP and ROD amendment would include public participation in amending the decision. ~~that a full design and perhaps some operating experience and data will be required to determine complete compliance.~~

~~"Summary of ARAR Compliance~~

~~"In terms of ARAR compliance, Alternatives D and E~~...((strike to end of paragraph. Compliance with ARARs is a threshold criterion. If any of the alternatives A-E does not meet ARARs (i.e. those without available waivers), it should not be in the running for the final detailed analysis.))

"4.3.7 Overall Protectiveness of Human Health and the Environment

"The potential risk to human health and the environment, ~~although still very low~~, is highest under the No-Action Alternative A, followed by Alternative B, the remediate shallow aquifer only alternative. Both these alternatives present risk of contaminating the deep aquifers utilized for irrigation and drinking water purposes by relying on only natural attenuation mechanisms and irrigation practices for dispersion of contaminants. ~~Potential risk from existing exposure pathways has been shown to be of little to no concern in the Risk Assessment (IT, 1988b).~~ ((The proper place for such statements is in the summary of site risks or in the RI, not here.))

"under Alternative C, the amount of contaminant capture is expected to be high, but mass balance releases to the environment may be increased in terms of quantity and rate. ~~Air permit requirements may come closer to being exceeded or reach a level requiring more monitoring.~~ ((This should be discussed under Implementability.)) The entrainment of lesser contaminated waters into the treatment system may result in lower percent contaminant removal.

"Alternative D appears to present the best match of protection in all media. ~~The rate of contaminant removal is well matched to air permit requirements so as not to exceed monitoring requirements thresholds.~~ ((This is an artificial constraint as far as the Agency is concerned; therefore it is not a consideration. It may be included in the Implementability Section, however.))..."

"Summary of Overall Protection

"Alternative D provides the best compromise between ~~allowable air emission~~, contaminant capture, treatment efficiency, and respondent protection of health and the environment. Alternative C may extract the greatest amounts of contaminants, ~~but removal from the treatment stream and high air emission levels in reference to the air permits may occur.~~ but result in lower removal efficiency. ..."

...Skip to page 4-35, Paragraph 2, last sentence:

"As such, Alternatives C and D are expected to allow greater contaminant capture than Alternative E, ~~and a lower probability of treatment plant under utilization due to lack of production from the intermediate zone.~~ ((This is not a consideration here.)) ..."

DHS Response:
Section 4.3.6: The text has been revised to state that Alternatives A and B do not include remedial action and that an indeterminate time period would be involved for reaching clean up levels in the aquifers. All other suggested changes have been incorporated into the text.

Summary of ARAR Compliance: This is an editorial comment that would not change the conclusion of the FS/RAP. The "Summary of ARAR Compliance" section does not specifically state which ARARs will be violated nor which waivers would need to be invoked; however, with the additional language requested for Section 4.3.6., this summary is no longer necessary and has been deleted.

Section 4.3.7.: All recommended deletions have been made.

"Summary of Overall Protection": DHS feels that the statement "... allowable air emissions..." should remain in the text. Air emissions from the treatment plant could present a health risk if allowable concentrations are exceeded, and therefore should be considered under overall protection.

The remaining deletions and additions indicated have been incorporated into the text.

9. EPA Comment:
The wording which was added in the ARARs section, regarding the contingency if ARARs are not met, should be added to each (accept for Alternative A) of the final alternatives discussed:

It is recognized that the results of computer models have limitations, and therefore the best available predictions of ability and time to meet ARARs may not be accurate. This is not expected; however, this remedial alternative would include evaluation of system operations and effectiveness at periodic intervals. ((specify as closely as possible)) Should the ability to obtain remediation goals become doubtful, the RAP will be amended accordingly and/or the appropriate ARAR waiver invoked. Any such RAP and ROD amendment would include public participation in amending the decision.

DHS Response:
This statement with some minor modifications will be added at the end of each alternative discussion (except for A):

It is recognized that the results of computer models have limitations, and therefore, the best available predictions of ability and time to meet ARARs may not be accurate. Therefore, this remedial alternative would include evaluation of system operations and effectiveness on a semi-annual basis based on monitoring data. In the event remedial goals cannot be achieved, the RAP/ROD may be amended accordingly by invoking the appropriate ARAR waiver. Any such RAP/ROD amendment would include appropriate public participation.

10. EPA Comment:

Page 4-29 does not mention the permit limits on the air stripper, nor for the NPDES permit. This is critical information to the FS as it is a primary ARAR for the preferred alternative. The discharge limits, for mass rate and contaminant loading, where applicable, should be provided in full and be easily accessible.

DHS Response:
The maximum flow rates for the air stripper and NPDES permits are given on page 4-28. In addition, copies of these permits are included in Appendix A for reference. For clarity, the text was revised to refer the reader to Appendix A.

11. EPA Comment:
The plume diagrams shown in the simulations show a piece of the intermediate zone plume moving off downgradient. While the capture zone figures seem to show that the plume is captured, there is uncertainty. This is an extremely critical issue. The RAP should be explicit as to the testing to be performed and as to how extraction wells shall be sited in order to ensure that the plume is captured. The following suggested language is provided to be added to all alternatives at the point that well siting is discussed. This pertains to Alternatives C, D, and E:

A primary objective of the remedial effort shall be to ensure that the plume of contaminants in the intermediate aquifer is completely contained. Accordingly, once the new extraction wells are installed, they shall be immediately sampled for contaminants to determine the real concentrations at the well points. If necessary, one or more additional wells will be installed further downgradient and/or pumping rates adjusted to ensure that the capture zone is completely containing any portion of the plume with contaminant concentrations above the cleanup level for any contaminant.

Once pumping has commenced, aquifer tests shall be performed to verify the true zone of capture for the wells. If necessary, another well will be installed further downgradient and pumping rates adjusted accordingly so that any portion of the plume containing concentrations above the cleanup levels for any contaminant is contained. The results of this assessment shall be reported to DHS and copied to EPA.

DHS Response:
The concerns raised in this comment are mainly the result of the limitations of the computer models used. However, these limitations are not spelled out, and therefore the diagrams could easily be misinterpreted by the uninitiated reader.

In order to mitigate this potential problem, the text has been revised to state that a primary objective of this remedial effort shall be to establish a zone of capture for the chemicals above cleanup levels in the intermediate aquifer. New extraction wells will be sampled for contaminants. If necessary, additional wells will be installed further downgradient and/or pumping rates adjusted to ensure that the capture zone intercepts any portion of the plume with contaminant concentrations above the cleanup level.

The inclusion of the following statement, "The results of this assessment shall be reported to DHS and copied to EPA" is not necessary in this report as it will be included in the Remedial Design.

12. EPA Comment:
Given that there is contamination in the deep aquifer (below the 120-foot zone) there should be a contingency in the RAP for the possibility that the deep zone comes to have contaminants above the cleanup levels. Such a contingency could likely be carried out by adding more wells in the deep zone and modifying the treatment plan (including the NPDES and air permit) to increase plant capacity. This would probably require a public notice but would not represent a fundamental change to the remedy and thus would not require a RAP or ROD amendment nor a second public comment period. The probable schedule for implementing such a contingency system, along with the general design parameter, should be included.

In order to plan for this contingency, Firestone should submit requests for "contingent" NPDES and air permit modifications to the appropriate agencies immediately. These would request approval for flow rate increases in the event, and only in the event, that deep aquifer levels go above the cleanup levels. This approach has been used effectively on other sites. This would allow action to be taken quickly if pumping in the deep aquifer becomes necessary.

It is recommended that a contingency plan, including such permit requests, be spelled out in the RAP to address this possibility. This should indicate that public notice, via local newspapers, would be given if such changes are carried out.

DHS Response:
Modifications to the existing NPDES permit is not an option available to Firestone at this time. DHS discussed this contingency with the Regional Water Quality Control Board and was told that the the Board will not issue contingent

NPDES permits. In addition, it is DHS' opinion that cleanup of the deep aquifer by EPA's proposed method would require major modifications to the existing treatment plant and significant increases in groundwater extraction rates. Such changes would require amendments to the State's RAP, and also an additional public comment period.

As a contingency in the event that the intermediate aquifer extraction system is not found to be effective in maintaining chemical concentrations in the deep aquifer below the established cleanup levels, the regulatory agencies will re-evaluate the extraction system and deep aquifer, and take the appropriate actions.

A contingency for the deep aquifer has been added to section 5 which will include monitoring of the deep aquifer and an evaluation of the intermediate zone extraction well system. If any chemical concentration is found above its cleanup level, monitoring of that well will be increased. If the concentration of any chemical in a domestic or drinking water well in the deep aquifer remains above its cleanup level within one year of the initiation of pumping in the intermediate aquifer or if any concentration is found at any time to exceed ten times its cleanup level, then a well head treatment system shall be established for that well or an alternate drinking water source shall be provided. If the same conditions are found for the deep aquifer agriculture wells, the crop testing program specified in the Remedial Action Order will be instituted.

If after eighteen months of the initiation of pumping in the intermediate aquifer the concentration of contaminants in the deep aquifer remains above cleanup levels or above ten times the cleanup levels for more than three months, then Firestone will submit to DHS within 90 days, and in accordance with the requirements of the involved agencies, a proposal for modifying the remedial system to include the deep aquifer.

In addition, if data from the deep aquifer monitoring wells indicate that the downgradient extent of contamination of the deep aquifer is no longer known, then Firestone will install additional monitoring well(s) until the extent of the plume is known again.

13. EPA Comment:
Figures 3-2 through 3-8, 4-1, 4-2, 4-3, etc. show contours without labels. These should be labeled with the appropriate level and units. If these are 6 ppb contours for DCE, it should be shown or discussed in the text as to why DCE is a valid indicator for plume extent. Are there instances where DCE is below 6 but other parameters are

above their cleanup level? Where might this be true? Indicate in the text.

DHS Response:
Contours in figures 3-2 through 3-8, 4-1, 4-2, etc. have all been appropriately labeled. Monitoring well data shows that DCE or TCA is the dominant chemical found in the wells. In addition, the rational for using DCE is included in Sections 2 and 3 as stated earlier.

B. DHS Responses to Public Water Supply Branch (PWSB)

1. PWSB Comment:
Section 2.2.2 Allowable Concentrations Based on Risk Assessment

The maximum contaminant levels (MCL) for several organic chemicals listed on page 2-2 need to be revised and incorporated into the list. The chemicals, MCLs, and effective dates are as follows:

Chemical	MCL (ug/l)	Effective Date
Carcinogens:		
1,2-DCA	0.5	April 5, 1989
PCE	5	May 5, 1989
Benzene	1	February 25,1989
Noncarcinogens:		
1,1-DCE	6	February 25, 1989
Ethylbenzene	680	February 25, 1989
Xylenes (*)	1750	February 25, 1989

(*) For a single isomer or sum of isomers

DHS Response:
The MCLs on page 2-2 have been revised to incorporate the list provided.

2. PWSB Comment:
Section 4.0 Detailed Analysis of Remediation Alternatives

The Public Water Supply Branch concurs that Alternative D is the most feasible, timely, cost effective, and technically acceptable alternative available to decrease contaminant levels in the intermediate aquifer. However, the PWSB has concerns with respect to remediation of the deep aquifer.

In reviewing the various alternatives, there is no provision to continue to monitor the deep aquifer wells, for an assessment of the data, and for a determination to be made if remediation of the deep aquifer is needed. It appears that final remediation will only be limited to the intermediate aquifer. In Fact Sheet #9, June 28, 1989, there is no indication that contamination of the deep aquifer has occurred.

Data from the Harden 12 AG well has been used to determine the trend of concentrations of chemicals in the deep aquifer. This source shows a decreasing trend of 1,1-DCE over a three year period. Based on this trend, the report has indicated that a downward trend is also expected of Wells ITM17A and ITM18A, which have 1,1-DCE levels above drinking water standards.

In addition, the report indicates that "Because agricultural use of the water has generally decreased the concentrations to a relatively low level of chemicals in the aquifer or has prevented large increases of concentrations of chemical, and, this can be expected to continue in the future, no alternative requiring additional extraction wells are planned for the deep aquifer."

A review of data from other deep aquifer wells, specifically, California Water Service company Station 21, Well ITM117A, and Well ITM18A, shows an increasing trend of 1,1-DCE over a one to three year period. Based on the trend of these wells, the proposal of no need for remediation of the deep aquifer seems premature.

The PWSB recommends that: (1) the deep aquifer wells continue to be monitored during remediation of the intermediate aquifer, (2) water quality data from the deep aquifer wells be reviewed to determine if contaminants present are at an acceptable level for public health protection, and (3) the need for further remediation of the deep aquifer be based on water quality data from the deep aquifer wells, not the intermediate aquifer wells.

DHS Response:
DHS is in agreement with the PWSB. Firestone is currently required to monitor the deep aquifer and will continue to be required to monitor the shallow, intermediate and deep aquifers in order to verify that no chemical concentrations occur above the cleanup levels established by this RAP. If any chemical in any monitoring well sample is found to be above its cleanup level, and the analysis is confirmed, the treatment plant will be started up again.

The monitoring period for groundwater will continue for 5 years from the start of the initiation of the final remedy or for a two year period after reaching cleanup levels, whichever occurs later. Chemical concentrations must remain below cleanup levels for an uninterrupted two year period or the two year monitoring period will begin again.

As a contingency in the event that the intermediate aquifer extraction system is not found to be effective in maintaining chemical concentrations in the deep aquifer below the established cleanup levels, the regulatory agencies will re-evaluate the extraction system and deep aquifer, and take the appropriate actions.

Please refer to EPA comment number 12 for a description of the contingency.

3. PWSB Comment:
Table 2-5, Organic Constituents, Water Quality Goals - Human Health and Welfare

The State adopted MCLs for tetrachloroethylene (PCE), 1,1,1-Trichloroethane (TCA) and Trichoroethylene (TCE) need to be added under the heading of "State and EPA Drinking Water Standards, MCLs, State". The MCL and effective date of the chemicals are as follows:

Chemical	MCL (ug/l)	Effective Date
PCE	5	May 5, 1989
TCA	200	February 25, 1989
TCE	5	February 25, 1989

DHS Response:
The MCLs for PCE, TCA and TCE have been added to Table 2-5.

C. **Comment from Office of Planning and Research:**
The State Clearinghouse submitted the above named environmental document [Firestone Tire and Rubber Co., Remedial Action Plan SCH# 89062710] to selected state agencies for review. The state agency review period is now closed and none of the state agencies have comments.

DHS Response:
None required.

D. **Comment by Roy W. Fowler, Jr.:**

At our meeting on April 19, 1989 at Spreckles, representatives of Firestone Tire and Rubber Company reviewed salient aspects of the Remedial Action Program and the proposed Negative Declaration for the above captioned project.

Since I have not heard anything further as to the schedules for public comments, I am forwarding a letter to you that I sent to

Firestone which, in part, describes the general area of my concern, i.e., well abandonment and recharge.

Please place this letter into the file as my interim comments and please send me your most recent schedule for public comment time.

DHS Response:
DHS acknowledges that there is a proposal to reuse the treated water from Firestone's treatment plant and to install more production wells. Any new proposals of this nature would have to consider the impact on the migration of the groundwater plume as well as its impact on the recharge of local groundwater flow by addressing the issue in an Environmental Impact Report.

E. July 13, 1989 Public Meeting:

Comments and responses may be found in the copy of the meeting transcript which is included in this summary as appendix A.

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APPENDIX A

PUBLIC MEETING
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

SALINAS HIGH SCHOOL AUDITORIUM
JULY 13, 1989
7:00 P.M.

DEPARTMENT OF HEALTH SERVICES:
Ms. Shirley Buford
Mr. Ric Notini

FIRESTONE:
Dr. Alan Altenau

IT CORPORATION:
Mr. Chan Weisel
Dr. R. Nichols Hazelwood
Mr. R. Leonard Allen

HEARING COMMENCED AT 7:20 P.M.

SHIRLEY BUFORD: Good evening, ladies and gentlemen. I'd like to welcome you tonight to the Remedial Action Plan and the negative dec and the proposed alternatives meeting for the Firestone site facility here in Salinas.

My name is Shirley Buford. I am with the Department of Health Services, community relations coordinator, and I will be your moderator tonight and also will present to you the speakers from the Department of Health, Firestone, the IT Corporation, and also there are members here from the Environmental Protection Agency and the Water Control Board - Central Coast of San Luis Obispo.

I would like to talk with you just a little bit about the purpose of this meeting tonight. It is to involve you, the public, in the decision that will be made on the final cleanup plan for the Firestone facility.

Community relations is mandated by both federal and state laws and it usually involves us getting involved and getting into the community at the very beginning of discovering a site with hazardous wastes. During the process of the cleanup we hold public meetings, provide fact sheets and other information for the public, including making a place for documents to be placed for the public to come and look at; that's called an information repository. In this case the information repository is located at the John Steinbeck Library. And in that library you will find the nine fact sheets distributed by Firestone, information on the meetings that were held during the process of the cleanup, and various documents related to the cleanup at the site.

We also mandate that Firestone develop a mailing list and inform the community around the facility of the investigation and the cleanup work taking place there.

Tonight you all have picked up an agenda, I hope, from the front. We'd like to go through, for your information, the people who will be speaking to you tonight will be Mr. Ric Notini from the Department of Health Services. Ric Notini is the chief of the site mitigation unit.

We have Doctor Alan Altenau. Doctor Altenau is the director of technology for Firestone. He is responsible for all environmental work and research and development, including quality assurance and industrial hygiene.

Next on our agenda is Mr. Chan Weisel who is the general manager for IT Corporation for Northern California. He is the project director for the

Firestone Salinas works.

Doctor Nick Hazelwood is the senior technical specialist and route manager for the IT Corporation, and he is in charge of preparing Firestone risk assessment.

And finally on our agenda we have Mr. Leonard Allen who is the senior project manager and geotechnical engineer in charge of the Remedial Investigation and Feasibility Study for the Firestone facility.

After the presentations, we will put together a question and answer panel. And there is some other agency people I will introduce to you later who will be available to answer questions on the site, on the Remedial Action Plan draft, and the proposed plan for cleanup.

At this time I'd like to introduce Mr. Ric Notini from the Department of Health Services.

RIC NOTINI: Thank you, Shirley.

What I would like to do over the next few minutes is briefly describe the process of cleaning up a hazardous waste site in California.

The State Department of Health Services is responsible for investigating and remediating hazardous waste sites in California. We are presently involved in the investigation and cleanup of over 300 sites across the state, and Firestone is one of those sites.

The topic that I am supposed to talk about is the state process. What that really refers to is a process that we have established to help insure that these sites are cleaned up to a satisfactory degree. Every site that we're actively working on is described in a report called Expenditure Plan for the Hazardous Substance Cleanup Bond Act of 1984. It was a law that was passed in 1984 that provided us funding to oversee the investigation and cleanup of the sites. So Firestone is one of the 300 sites that's discussed in this report. And this report also describes in a lot more detail the process that I am going to briefly go over.

I want to first mention that the process of investigating and cleaning up a hazardous waste site involves a lot of different agencies and requires a lot of coordination. And I just want to acknowledge the assistance and help that we have gotten from a number of other agencies including the Monterey County Health Department, the Regional Water Quality Control Board, and the Federal Environmental Protection Agency. We do have representatives from those agencies here, so if you come up with a question specific to that agency, we'll ask them to help us out.

I have a couple of overheads I want to show and I am going to have to step away from the mike, so I will try to speak up a little louder.

This overhead shows the two laws that we use to investigate cleanup sites. There is the Federal Superfund Law, which is also -- the long name is actually called the Comprehensive Environmental Response Compensation and Liability Act, commonly referred to as Federal Superfund. And the State Superfund Law has the Hazardous Substance Cleanup Bond Act. These are the two laws that provide us the authority to investigate and cleanup these sites.

Now this Firestone site is actually considered both a State Superfund site and a Federal Superfund site. Back in 1987 the Firestone site was proposed or actually added on to the Federal Superfund list, which is known as the National Priorities List. So the cleanup is going to have to satisfy not only State requirements, but Federal requirements as well.

If I could show the next overhead. This gets into the cleanup process, and I will move through this rather quickly. The first step involves discovering the site. And the first thing we do when we receive either a complaint from a citizen or a report from a company or perhaps another agency refers some information to us indicating that there has been a leak or spill of a hazardous substance, we conduct a preliminary site assessment. We try and determine if there has, in fact, been a spill or leak, whether or not that spill or leak presents an actual or potential threat to public health or the environment.

Based on that, if we decide it it looks like a significant enough of a problem, we move to the next step, which is the Remedial Investigation. What that really means is defining the problem, finding out what is the nature and extent of the contamination, and what kind of a threat does it pose to public health or the environment. That study involves going out and collecting samples of soil, air and groundwater, very often, and typically takes several years to complete.

Now during that time if there are some things that we can do right away to begin to address the problem, we call those interremedial measures. And, in fact, at the Firestone site back in '84 and '85, they actually excavated contaminated soil and installed some wells and began extracting some of the contaminated groundwater.

Once the Remedial Investigation is completed the next study we perform is a Feasibility Study, which really means trying to determine what's the best way to complete the cleanup, looking at various alternatives. And that is what was recently completed by Firestone.

In addition to that, the next step involves preparing a Remedial Action Plan. And the Remedial Action Plan summarizes the results of the Remedial Investigation and Feasibility Study and discusses the cleanup alternative that is being proposed.

In addition to that we are required to hold a public meeting and provide for a 30-day public comment period. And we review and solicit comments from you and review those comments, prepare a written response to those comments before approving of a final Remedial Action Plan.

So Shirley mentioned that we have a public comment period now which ends, I believe, the 27th of July. You have until then to provide us with your comments. We will review those and then try and approve of a Remedial Action Plan based on the comments we have received.

Following the Remedial Action Plan, Firestone will be required to prepare a remedial design, which involves all the engineering design necessary to install the systems that they propose. Then they are required to implement it and operate and maintain it for as long as necessary. I might mention that all of this work up to now has been done by Firestone and paid by Firestone under oversight of the Department of Health Services.

The last thing I wanted to discuss is the California Environmental Quality Act. As part of the process of investigating cleaning up the site, we must also make sure that we are complying with other state laws. The California Environmental Quality Act is one of those laws that is applicable.

We have prepared a document known as an Initial Study. And based on that study we have determined that the proposed cleanup will not have any significant environmental impacts; therefore, we have filed a proposed negative declaration and do not plan on performing an environmental impact report. That is also an item we are interested in receiving your comments on. So we have proposed a negative declaration for this site.

That is all I have to say. The speakers following me will specifically discuss the Firestone site and I will be available for additional questions you might have. Thank you.

SHIRLEY BUFORD: Thank you, Ric.

The next speaker is Doctor Alan Altenau from Firestone, and he is the director of technology for Firestone.

Doctor Altenau?

ALAN ALTENAU: Thank you very much and good evening.

I would like to briefly discuss some of the background of the site and a brief overview of the work and progress that has gone on since environmental investigations have begun back in 1983.

Firestone manufactured tires at the Salinas plant from 1963 to 1980. The plant was closed in 1980, and during the closure of the plant, equipment removal and so forth, environmental investigations were begun. These investigations were begun in cooperation with the Department of Health Services of California. During these investigations we noted there was some soil contamination and some contamination of the groundwater.

In 1984, proceeding along with our investigations, we moved to the off-site area as we were beginning to learn more about the on-site contamination that existed. Also in 1984, as a result of the 1983 investigations which indicated some soil contamination, we removed over 5,000 cubic yards of contaminated soil and disposed of that soil properly. That really begun an approach that we followed throughout this investigation and study as where we found contamination, we immediately took remedial action to correct that problem rather than waiting for all the investigations to be finished. So this was the first piece of remedial action that we have carried out by removing all the soil. We also removed underground storage tanks and any contaminated soil that might be associated with the removal of these tanks.

In 1985, again as a result of some of the initial investigation showing contaminated groundwater on-site, we began construction of an on-site groundwater extraction system and treatment plant. So as the water would start moving from on- to off-site, we could capture that contamination before it would leave the site. So that construction was begun in 1985.

Now the chemicals that we showed as contaminants in the soil and groundwater were several chlorinated type of chemicals. These chemicals typically were used -- some of these chemicals were used in the cleaning of equipment. So during that, small amounts of spillage in the cleaning of equipment, some of these chemicals got in the soil, went through the soil, finally into some of the groundwater. And some of the chemicals really resulted from degradation, natural degradation of these chemicals in the soil to other chemicals. So it wasn't chemicals used in the manufacturing process, but small amounts of chemicals used to clean equipment, things like that.

In November of 1985 an extensive amount of crop testing began. Various crops were tested to determine whether there was any takeup of any of this contamination during the irrigation process. The results showed there was no chemical contamination in any of these crops. The same kind of investigation continued off and on over a period of time and further verified there was no contamination present in these crops.

In 1986, start of the treatment plant began, again capturing contamination in the groundwater before it would go off-site. This contamination that we're extracting is what we call in the shallow aquifer down to about 90 feet. When we use the term "aquifer," that means different bodies of water in the groundwater, and sometimes they are separated by clay layers. And in the site here we have different aquifer levels, maybe 100, 200, 300, 400 and so forth. So we have investigated over time these different aquifer levels, which are bodies of water separated by impermeable clay layers. So this extraction plan was extracting and cleaning water up from the shallow aquifer, roughly 90 foot aquifer, before it leaves the site.

In August of 1986 the Department of Health

Services approved an off-site deep groundwater investigation plan. This was a plan designed to very thoroughly investigate the off-site area -- very far off-site actually -- to determine the extent of contamination and to better define where the contamination is. The results of this investigation indicated that the contamination off-site is a rather narrow band of contamination which we would call a plume, but it's just an area where the contamination exists. But it was not wide-spread, it was somewhat narrow. And the plan also indicated why it stayed narrow due to the geological formations around the area.

In 1987 we continued routine well sampling and that showed no additional agricultural or municipal wells with contamination. We continually monitor various wells. And this is just a note that 1987, at that point since the investigations began in 1983, we found no additional well contamination in the agricultural or municipal wells. And I think part of that is the quick remedial action we have taken at the beginning in removing quite a bit of all the contaminated soil as well as putting an on-site extraction treatment plant functioning to reduce the possibility of further contamination of going off-site.

In April of 1987 DHS approved well locations for the off-site shallow aquifer extraction system. The on-site treatment plant stopped contamination from going off-site. But we have now wanted to start cleaning up contamination that went off-site before the on-site treatment plant began operation in early 1986. So here we were proposing, and DHS approved, putting additional extraction wells roughly a third of a mile off-site to capture contamination before it would go from the 90-foot aquifer to a slightly lower aquifer.

In 1987, just a note, contamination levels in the groundwater continued to decline, again based upon the early remedial action that was taken.

In July of '87, we started off-site extraction system construction. After this plan was approved, then in July that year we started construction in September. This off-site extraction system began taking extracted water from the 90-foot aquifer off-site and bringing it back to our treatment plant.

In November of 1988 DHS approved a risk assessment that was carried out. This risk assessment was carried out using the guidelines of protocol of the US EPA and the California Department of Health Services. The conclusion of this risk assessment was there is no current risk to human health from the contamination at this site.

In December of 1988 we issued a very extensive Remedial Investigation report, which is really a compilation of all the analysis, results and conclusions that took place over these years during our investigations.

In June of this year the Department of Health Services approved this Remedial Investigation report. During the time they were reviewing this report we were preparing a document called a draft feasibility study. And this was a document really which follows from the Remedial Investigation report, which by looking at the results of this Remedial Investigation, what would be appropriate alternatives for further additional remedial action. And a number of alternatives were listed and considered. And from these potential alternatives for future remedial action, a document, the Remedial Action Plan, would follow which would be the selection of the most appropriate alternative listed in the draft feasibility report. And tonight later on we will be discussing the proposed Remedial Action Plan for further action at this site.

In June of 1989 DHS announces a proposed final cleanup plan which followed from the Feasibility Study and is now part of the Remedial Action Plan, and that was discussed in fact sheet number nine.

As mentioned previously, DHS proposed a negative declaration for the Remedial Action Plan which says that DHS does not see any environmental problems from carrying out this Remedial Action Plan that is proposed.

June 27th, published notices for public meeting and a comment period, which is one month. We're having a public meeting today and the comment period ends July 27th.

So that's a very brief overview of the work and progress that has gone on over these last number of years.

WALTER WONG: Doctor Altenau, I know this is the wrong time, but I think it's important while you're there and before people leave to watch the Bill Cosby Show at 8:00 o'clock, there is a question you need to answer at this time because I have received quite a few calls about it. Because apparently in the medias it was reported that you found new contamination at a deeper aquifer, and I wasn't aware of this because I am of the understanding that levels have always been below action levels. Can you clarify that now while everybody is here?

ALAN ALTENAU: Would you put a couple of slides back up, please?

We put an off-site extraction system in in September of 1987 -- this is again about a third of a mile off-site in the 90-foot aquifer, shallow aquifer. We put this extraction system in to stop further contamination from going from that level to a lower aquifer, namely the 120-foot aquifer. We knew some had taken place. But we wanted to first put this extraction system in to remove most of the contamination in this level before putting extraction wells in the 120-foot aquifer so we wouldn't draw down the contamination in the 90-foot aquifer. We wanted to do a substantial amount of cleanup and then install extraction wells in the 120-foot aquifer, which is the proposed plan. The amount of contamination in the deep aquifers -- 200, 300, 400, and 500 -- have never exceeded the state action level during all these investigations. So due to the Remedial Action Plan that we have had early on as well as continuing throughout, the deep aquifers always had action levels below the state action limit.

WALTER WONG: So it is not a problem?

ALAN ALTENAU: It is not a problem in the deep aquifers and we continually monitor the deep aquifer. If anything, we continually see it decline in values in the deep aquifer, which one would expect because the remedial action has taken place.

WALTER WONG: Okay. Fine.

SHIRLEY BUFORD: Thank you, Doctor Altenau.

And with that I would like to introduce the person, the gentleman who asked the question, Doctor Walter Wong, who is representing you from the Monterey County Health Department, and obviously he is very concerned about this site. And I would just like to let you know who that was asking the question. Thank you.

Next on our agenda is Chan Weisel, general manager for the IT Corporation. And he will talk about the progress that's been made in the cleanup so far.

CHAN WEISEL: Thank you, Shirley. And also, welcome to our meeting this evening.

What I would like to do is simply give a little more information on the progress that has been made, the actual cleanup or remediation progress over the last several years.

As Ric mentioned, we have been involved in what is called interremedial measures, IRM's, which is actual cleanup work done before all the investigation is complete and before the final cleanup plans are set.

Literally most of the cleanup has been completed. As mentioned earlier, soil -- contaminated soils and underground tanks have been removed, all disposed at licensed hazardous waste facilities.

Doctor Altenau mentioned the various activities giving the dates and all. What this figure will show you is -- well, it will simply put it in perspective as to where things are.

This is the large building, the former Firestone facility. And you see at the south end the treatment plant which was installed in 1985 and operational in early 1986. In that same time frame was the installation of 15 water extraction wells, groundwater extraction wells on-site. And they are along this line. They are piped all to the treatment plant, the water is treated and then discharged to the Salinas River.

The off-site extraction wells referred to earlier are about a third of a mile away from the plant or the property line. And there are five of them and these were installed in 1987 and operational just about two years ago. The water from these wells is pumped through a pipeline along the farm roads to the treatment plant.

The groundwater plume referred to is a narrow band of contamination starting essentially in the middle of these on-site of this on-site well area or at least that's where the highest concentrations exist and moving in this direction, and this is in the shallow aquifer, the uppermost aquifer about 90 feet down. So it's this narrow band of contamination moving in the shallow aquifer that all of our work, all of our groundwater work has been intended to remove -- remove the contaminants from.

Later you will see slides which will show the next and we believe final phase of work which will be extraction in the 120-foot layer. And again as Doctor Altenau mentioned, there is no significant contamination in the deeper aquifers and therefore no remediation plan.

What I would like to show you now are three contamination concentration curves which I think dramatically shows the progress and the accomplishments of the cleanup to date. I showed you the line of 15 on-site extraction wells. This first curve is an average of the extremes of that line, the uppermost wells and the lowermost wells. And as you can see, three years ago concentration average was about three parts per billion. Most recently we're down to under one part per billion. The action level -- drinking water action level is six parts per billion so we're well below that. So that is, we feel, a real accomplishment. These concentrations by the way are for DCE, one of the chemical contaminants and the main one that we have tracked.

Same kind of curve here, but for the center of the plume or where the center of the on-site extraction wells are. And here, instead of starting at 30 parts per billion, we were over 400 parts per billion and have brought that down to five. So that's essentially a hundred fold decrease. You can see why I am saying that the bulk of the cleanup has been completed. Again the action level is six, so we're below the action level in the on-site area.

Last concentration curve for the off-site extraction wells which were started up in 1987, the average concentration at that time was about 65 parts per billion, currently running about 16. So we're still slightly above the action level, but coming down nicely.

I think this final slide on the accomplishments summarizes well. It shows the actual area of the contaminant plume in the groundwater at different periods of time.

Again here is the former Firestone facility, the line of on-site extraction wells along here and the off-site extraction wells shown here. This is the plume area at six parts per billion or the action level for each of the years 1986, '87, '88, and '89.

And as you can see in 1986 the area was quite large covering all of the area of the on-site extraction wells. One year later after the treatment plan had operated for a year, major reduction in plume area. The next year 1988, even a greater reduction. In 1989 so far, this is the area. That's about an 85 percent reduction in plume area during that three-year period. So we feel that a lot of the remediation again has been completed and we're well on the way. You can see here I talked about the narrow plume. You can see how narrow that is at this time.

Thank you, Shirley.

SHIRLEY BUFORD: Thank you.

Next on our agenda we'll present Doctor Nick Hazelwood, senior technical specialist and group manager for IT Corporation and he will talk to you about risk assessment at the Firestone facility.

NICK HAZELWOOD: Thank you very much, Shirley. I hope you can all hear me. If you can't put your hands up.

When we talk about risk assessment there are two things you have to keep in mind. First of all, the only time you have a risk is when there is both a hazard, the presence of a hazardous material or a hazardous situation and someone is exposed to it. If you have a hazardous material and no one is exposed to it, there is no risk until that exposure happens. So when we analyze risk assessment, we both analyze for hazards and for possible exposures.

In identifying the hazards at this facility we looked for the types of chemicals that are present in the soil and the groundwater and looked at the effects or potential effects on human health and/or the environment.

These are the chemicals that are the indicator chemicals that were found at the site, and we talked about chlorinated solvents and aromatic solvents that were used. 1,1 DCE, which is this one here, 1,1 dichloroethene, also known as vanilladene chloride as a compound, is actually a degradation product of 1,1,1 trichloroethane, which is the principal solvent that was used. When this material gets in the soil and water it is broken down from natural processes to this compound. This is the compound that is present in the highest concentration and is what we use as our indicator. That's why all of our graphs are showing 1,1 DCE. The other compounds are there, they are there in lower concentrations. So this is the easiest one to track and this is the one we're working on to reduce to accepted levels. Next slide, please.

When we look at exposures, we look both at the media that could be delivering the substance -- air, drinking water, irrigation water and soil on the one hand -- and the routes of exposure -- inhalation, ingestion or skin contact.

Out of all those possible combinations of 12 or so, these were the three that we isolated as being the possible routes or pathways that could lead to risk. Obviously drinking the drinking water contaminated with the substances that were found.

Second, air emissions from the treatment plant, because there is an air stripper in there, or from water used for irrigation and evaporation of these chemicals from the irrigation water. Analysis of this showed that the concentrations in air were well below the accepted levels as set by regulatory agencies for air emissions from both DHS and the Monterey Unified Air Pollution Control District requirements.

Crop uptake, as Doctor Altenau told you, has been studied extensively. There is no data to show that there is any uptake by these chemicals by the crops grown in the crops in the field using the irrigation water. So we can basically "X" out these two. They are potential, but not actual pathways. So our analysis and risk assessment has focused on the drinking water issue. Next slide, please.

The risk criteria that are laid down for our cleanup is that substances that are carcinogens that could cause cancer, that the amount in the drinking water must be small enough so that the lifetime additional risk from drinking that water for 70 years would be less than one in a million additional possibility of getting cancer.

Similarly for non-carcinogens, we calculate something called a health index. Now the health index takes the state action level, which as several people have mentioned for DCE is six parts per billion and says you divide the actual concentration by the number that is the action level and that number must be less than one. The action level, in other words, tells you what is the permissible concentration in drinking water that you could ingest without harm for non-carcinogens. And the sum of all of those things must be less than one. In other words, the concentration of all the non-carcinogens must be small enough so that there is no long-term adverse health effect from this water. Next slide, please.

We looked at different possibilities for drinking water. There is only one well in this area that is used for domestic purposes. So we said -- let us take some worse case situations. We will take a hypothetical well in the shallow aquifer, similarly one in the intermediate zone and one in the deep zone, and take the average concentration in each one of those and is there a potential health risk.

And this next slide summarizes the findings of the risk assessment. There is no potential health risk in the existing well if someone were to put a well in the shallow aquifer. And as Walter Wong will tell you, the County does not allow that kind of thing for a lot of reasons. But if it were done there would be a slight risk, which is of course one of the reasons why we're going and cleaning it up. Similarly the hypothetical intermediate and deep zone wells, again with the average concentrations, there is no potential health risk. Go ahead.

So the risk assessment conclusions, and this is quoted from the risk assessment, there is no present or future threat to public health. There is no present threat because our analysis shows no one is exposed. There is no future threat because there is a cleanup plan which is going to be discussed by subsequent speakers that will remove the last residue of the hazardous material so that there will be no future threat to public health.

SHIRLEY BUFORD: Thank you, Doctor Hazelwood.

Our last speaker on the agenda is Leonard Allen and he will speak to you about the proposed Remedial Action Plan.

Mr. Allen?

LEONARD ALLEN: Good evening, ladies and

gentlemen.

My purpose this evening is to present the Department of Health Services proposed plan for you so you can see what the next stage will be so that you will have your opportunity to comment on that, get your input into the State.

The first speaker this evening, Ric Notini, covered the State procedures for evaluating a site such as the Firestone site and getting to the stage of having the proposed plan and actually implementing that through cleanup.

We can have the first view graph there, George.

The proposed plan that I will be covering tonight comes out of that portion of the process that Ric covered called the Feasibility Study. The Feasibility Study is really a very detailed engineering study that considers a wide variety of alternatives aimed toward cleaning up the contamination that has been found. And out of that Feasibility Study we select the best remediation alternative.

The proposed plan is based, to a large degree, on the Remedial Investigation report that was prepared in December of '88. That report has, as Doctor Altenau has mentioned, combined all the previous studies of the site, defined this plume or where the chemicals occurred in the groundwater. We have got this narrow region that looks like a cigar on one of the earlier slides. It's not spread out laterally quite a bit, it's fairly confined in there. Once we've got that area defined, then we can look at the remediation plan to cleanup that zone of chemicals in the groundwater. Earlier also we have discussed that the soils on the site that were contaminated were removed. So the proposed plan that we're discussing this evening is focused just on the cleanup of the groundwater which is left.

The Feasibility Study that was done for this site followed the very formalized, detailed Department of Health Services guidelines as well as the Environmental Protection Agency guidelines. The large variety of remediation schemes that were considered for the treatment, included a number of chemical, physical and biological processes.

We have also looked at other types of treatments such as a containment, if there is some way to contain the contamination where it was, concluded that pumping the groundwater out and treating it was the best alternative.

We can see the next view graph then. Once we have gotten to the point where we have selected a pump and treat alternative, then we have to look at the locations of the extraction wells. What wells are we going to pump from? Both horizontally, where are we going to locate the wells and what depths are we going to be pumping from?

It has been mentioned that there are 15 existing extraction wells on-site and there are five existing extraction wells off-site, all of those located in a zone shallower than 90 feet.

In addition, during the Feasibility Study we considered ten new well locations that would install wells down to the zone 120 feet deep. With those wells, all the existing and the proposed -- or the ten new wells that were evaluated, then we have the alternatives of adjusting the pumping rates to come up with the combined flow rate from the groundwater that's being extracted.

If that goes back to our treatment plant, then we have a variety of treatment alternatives. As we mentioned, we considered a large number of physical, chemical and biological treatment options for the low concentrations; that is concentrations in the parts per billion range that we're dealing with here at Firestone and the chlorinated hydrocarbons and aromatic hydrocarbons that are present at these low concentrations.

The Feasibility Study and the cleaning process leads us to the viable treatment options of being carbon absorption, the air stripping, and the other one being a combination of those two. That is what's been going on at the treatment plant for the last several years.

The other options that were considered were the options for how we discharged the treated water; that is, once the groundwater has been extracted and has gone through the treatment plant, what do we do with the water after it has been cleaned? We did consider three alternatives here. One was continuing the discharge into the Salinas River about a mile south of the treatment plant. This has gone on for the last three years. We considered injection of the treated water through wells located on-site. And we also considered disposal of the treated water into surface ponds just south of the plant area. The screening process that we went through led us to stay with the discharge to the Salinas River.

Looking at the combinations of the well locations and the pumping rates with these treatment options and the discharge options led us to define five alternatives that were studied then in greater detail.

The first alternative is called a "no action alternative." And for the Firestone site that would involve stopping what is going on right now, taking no further treatment action. That is -- that's required by regulations and is more to establish a baseline case for comparison with the other alternatives.

For alternative B, we looked at continuing the existing pumping and treating system; that is, pumping from the existing wells at a combined flow rate up to 650 gallons a minute. That's only pumping from the shallow aquifer.

In fact, we have two limitations on the flow rate that we can treat under the current conditions. The 650-gallon-a-minute treatment of the water is limited by the current capacity of the treatment plant. Actually with the pumping from the contaminated wells that we're doing right now and the declining groundwater table in this area, we can only pump about 450 gallons a minute from the existing wells.

The third alternative that we looked at showed that we would -- if we put in five new wells in the intermediate aquifer a little farther northwest of the plant from the five off-site wells that exist now and we pump those in combination with the current pumping from the shallower wells, we could pump at a combined rate of about 1150 gallons a minute. This does involve the five new wells to be constructed in the intermediate aquifer, it would also include an expansion of the existing treatment plant.

However, recognizing that is using almost double the pumping rate that we have been using in the past, when you use that much additional water we looked at the fourth alternative, which is similar to the third except that we adjust the flow rate so that the combined flow rate from all the wells, including the five new wells, does not exceed the 650 gallons per minute. That, in fact, is the alternative that has been selected by DHS for the proposed plan.

The fifth alternative, similar to the fourth, only that two additional wells would be installed in the intermediate aquifer, was that we would have fewer wells. We have recognized that by looking at a lower combined treatment flow of 600 gallons per minute for that.

Okay. These five alternatives were analyzed in detail and discussed in the feasibility study. There are nine evaluation criteria that are included in the EPA guidelines and used by Department of Health Services also.

We have broken up the evaluation criteria into four that we call the key criteria and five other criteria. Now these are not listed in terms of priority. Certainly if we were including priority, the overall protection of the human health and the environment would be high on the list rather than down under the other criteria.

The differentiation between the key criteria and the other are that the key criteria are the ones that help us differentiate more among the five alternatives that were studied in detail.

The first criteria, short-term effectiveness, lets us evaluate how effective the proposed alternative would be in a relatively short period of time.

Long-term effectiveness, on the other hand, is other than given enough time, how effective would the remediation be for each of the five alternatives?

The third key criteria was the one that US EPA calls a reduction of toxicity, mobility and volume. That's getting into the question of the permanence, how permanent is the proposed remediation?

The fourth key criteria is whether the proposed alternative complies with all the regulatory guidelines involved.

The other items, just to run through them briefly here since they don't help us differentiate greatly between the alternatives, are the implementability; that is, is there sufficient technology? Is there equipment? Is there manpower to actually implement the proposed remediation?

The sixth criteria would be the cost

effectiveness of the remediation.

The seventh, the overall protection of human health and the environment, would be either State acceptance and/or EPA concurrence with the plan.

And finally, the community acceptance, that's one of the purposes of the meeting this evening is to present the plan to the community and get the feedback from the community on how acceptable that plan is. When we apply these nine evaluation criteria to the five alternatives, we came up with the matrix that shows how these work.

If we look in terms of the first criteria, the short-term benefits, the first two -- no action and continuing the current operations -- do not do anything to remediate the chemicals in the groundwater in the 120-foot level. So they really don't achieve the short-term effectiveness. So we put "no" on there.

If we put in the five new wells, in the case of alternative C and D, pumping either 1150 gallons a minute or 650 gallons a minute, we have put "yes" in here. We do achieve the short-term effectiveness.

If we cut back to only two new wells, as in alternative E, we again have "no" for the short-term benefit. It takes us longer to achieve the cleanup levels with those.

So looking just in terms of the short-term benefit criteria, there are only alternative C and D that satisfy that criteria. The shaded zone D there, of course, is the proposed plan that is being presented to you this evening.

In terms of long-term benefits, the no action alternative would take a long time because there is no active remediation undertaken for that alternative. Given enough time -- that is, the long-term benefits -- all the other options do eventually achieve a long-term benefit.

Looking in terms of the reduction of toxicity, mobility and volume, we achieve it with the last three on the list here. We achieve it only in the shallow aquifer for alternative G and we do not achieve it in the terms of the no action alternative or alternative A.

Under the regulatory compliance evaluation criteria we did not comply with the regulations in case of the no action alternative, we do in the case of the other four; although in the case of C there would be some permit changes required to implement that.

So looking at the comparison of these alternatives we see that alternative D, the proposed plan, is the only one that satisfies each of these four key criteria as we go along here. Again, only alternative C and D on here achieve the short-term benefits.

So if we look at the differences now between C and D on here, we see that actually -- even though we pump almost twice as much, in the case of C we're pumping 1150 gallons a minute compared to 650 gallons a minute.

The time for the cleanup is really not that much different. We're controlled more by the cleanup in the 120-foot level than we are by the cleanup in the 90-foot level. And the time for the cleanup in the 120-foot level is essentially the same for alternative C and D. So we have the same time, the cost obviously is higher with the alternative C because it would involve expansion of the treatment plants, some additional capital costs, also time involved to achieve the new permits that would be required.

One of the other major differences between alternative C and D is that alternative C, which was not selected, would take twice the amount of pumping. So if there is an impact on the agricultural use of the water, it would be greater with C, which again leads us to alternative D as the selection.

D was selected as the final proposed cleanup plan because it achieves the rapid cost-effective cleanup and requires less groundwater to be pumped than alternative C, which is the only other alternative that achieves the short-term benefits criteria. We have a map here that shows the proposed five new wells.

As I mentioned earlier, we actually considered a total of ten different locations in the off-site area for wells in the intermediate aquifer. These are the five that we have selected and are included in the proposed plan -- three of them are located along Alisal Slough and two of them are located on existing farm roads. We have done this to minimize any impact on the agricultural activities out in that area.

Those five pipelines -- the five new proposed wells would be connected by a pipeline that would run along Alisal Slough and along Scarp Road and tie into the existing pipeline back about a third of a mile away from the existing treatment plant.

To summarize the proposed plan, we would plan to continue pumping from the existing shallow aquifer wells, although the pumping rates from the various wells would be adjusted depending on how the monitoring data came in. In addition, the five new wells would be installed in the intermediate aquifer. The plan right now would be to have those wells installed this fall. We would pump at a combined flow rate up to 650 gallons a minute from all the wells, both the shallow and the intermediate aquifer wells.

What we're accomplishing by this is that we will -- we lose the contamination in the intermediate aquifer and continue to reduce the contamination in the shallow aquifer as we have been for the last three years or so. We are also cutting off any migration of the chemicals from the 120-foot aquifer into the deeper aquifers. The treatment plant would continue operating as it has been for the last several years; that is, we would still be using the carbon absorption and air stripping units on the site. The discharge would continue to go into the Salinas River as it has been going.

By putting in the five new wells in the intermediate aquifer, our computer simulations project that we will significantly reduce the remaining cleanup time. We're projecting that the cleanup time will be about a year to a year and a half from the time that the wells and the 120-foot aquifer are installed. We have run over a hundred computer simulations in various combinations of well locations, pumping rates, projected the cleanup times.

Some of the alternatives, basically the five that we have discussed in detail here, are shown on the plots across the wall, if you would care to take a look at those during the break here prior to the question and answer period.

In addition, we do have several other maps, if you would like to take a look at those, those will be spread out on the table up in the front during the break period here.

Shirley?

SHIRLEY BUFORD: Thank you, Mr. Allen.

Okay. I think that's a lot of information to digest. We would like to take a few minutes to break so you can look at the other information and be ready for the question and answer period. So we'll take ten minutes and get into the question and answers.

(Break taken from 8:22 to 8:33 p.m.)

SHIRLEY BUFORD: Thank you very much. We'd like to get started on the second part of the program, the question and answer session.

We have got a number of agency representatives here, other than those who were making presentations tonight. And I have already introduced Walter Wong. Doctor Wong is sitting in the front. He represents the County Health Department -- Monterey County Health Department. Also we have got Bob Baldridge who represents the Water Quality Control Board - Central Coast. That is Mr. Baldridge. And Jeff Dhont from the Environmental Protection Agency. Jeff is up at the table. And you have met the other presenters, so we'd like to get started.

I would like to ask you to stand if you have a question and give your name, identify yourself. And if you want to ask a question of a specific person, please indicate that, otherwise we will get the answer for you.

So I would like to open the process now. Are there any questions?

ED FISHKIN: I have a question. There seems to be a very well thought out --

SHIRLEY BUFORD: Okay. Give us your name, sir. Please state your name.

ED FISHKIN: Ed Fishkin.

It seems to be a very well thought out mediation plan. Assuming that the computer projections are correct, in a year and a half from now all of the contamination levels are below the action level. How much longer would you continue to pump and how much longer would you continue to sample to make sure that the water is indeed clean?

SHIRLEY BUFORD: Thank you.

Mr. Allen, would you like to answer that?

LEONARD ALLEN: At the point where the concentrations in the groundwater have reached the cleanup levels, we would stop the pumping at that stage. The monitoring beyond that to see that there is no unusual buildup in the concentrations past that, we're anticipating now would take place for at least an additional two years.

ED FISHKIN: Thank you.

SHIRLEY BUFORD: Thank you.

Okay. The gentleman in the red. Would you like to stand and tell us who you are?

JIM LAND: My name is Jim Land from Carmel Valley. I was wondering, it seems to be apparent that the flow rate is something of a concern because of somewhat of a depletion of the aquifers. I was wondering why the water isn't injected back into the aquifer rather than dumped into the Salinas River.

And I have a second question too.

SHIRLEY BUFORD: Okay. Mr. Allen, will answer your first question.

LEONARD ALLEN: That's a very good question. In effect, we are recharging the water with the discharge to the Salinas River. The river bed is porous enough that the water that we're discharging does permeate back into the shallow aquifer system. In fact, the flow monitoring system that the Federal Government monitors downstream from us shows a lower flow rate than we're actually pumping into the river at the discharge.

So we are doing it, we're achieving the injection into the shallow aquifer system without the problems that inherent in injecting it through wells on-site. With wells on-site you have problems with siltation, you are not able to maintain the pumping into those injection wells.

SHIRLEY BUFORD: And you had a second part to your question, sir?

JIM LAND: Yeah. With all the available technologies of water cleanup possible, why was carbon absorption the chosen method here?

LEONARD ALLEN: The carbon absorption and the air stripping do turn out to be the most effective. You are limited with a lot of the other technologies because of the very low concentrations that we have in the waters to start with.

We're down in the parts per billion range. A lot of the technologies would not be effective in there. I'm not sure what other alternatives you are considering here, but there are other limitations with the other ones if you are looking at some biological treatments you have problems treating the chlorinateds at this low level. In fact with the biological treatments you have to have enough of the nutrients to keep the bugs alive, and we just don't have those high concentrations here.

We did look at probably 30 or 40 different alternatives. But for the chlorinated hydrocarbons and the aromatic carbons and activated carbon and the air stripping are the most efficient way to go.

JIM LAND: Thank you.

JOHN GOODRICH: Back to the original question. Any idea of what the re-absorption is of the water you pump out? You're saying it gets re-absorbed back into the aquifer; any idea what percentage?

LEONARD ALLEN: Well, it depends on how far downstream it goes. Eventually all of it is. The Salinas River is recharging the shallow aquifer in this area, so it's getting back in there. Quite a high percentage of it is getting back in.

SHIRLEY BUFORD: Can I get your name, sir?

JOHN GOODRICH: John Goodrich.

SHIRLEY BUFORD: Pardon me?

JOHN GOODRICH: John Goodrich.

SHIRLEY BUFORD: Goodrich. Thank you.

Anymore questions?

JIM ABELOE: Yes. My name is Jim Abeloe. I am interested in the 120-foot aquifer and the extent of contamination in the aquifer and the amount of the degree of contamination. The upper aquifer plume has been well-identified both in concentration and extent, and I would like to have that same information for the

120-foot aquifer.

SHIRLEY BUFORD: For the 120-foot aquifer you would like to know the contamination plan?

JIM ABELOE: Yeah. Whether you contemplate putting the plan in or something like that.

SHIRLEY BUFORD: Okay. Mr. Allen?

LEONARD ALLEN: Yes. There is a map in the feasibility study, which we have a copy of here if you would like to take a look at it. It shows the plume in the intermediate aquifer. That is similar to the shallow aquifer in that it's confined laterally. These are old alluvial sand and gravel channels that are filled in that the chemicals are going down basically. It's approximately the same width as the plume that we have in the shallow aquifer. The concentrations of DCE, as I recall, are about 15 to 2 on an average in that area --

NICK HAZELWOOD: Maximum.

LEONARD ALLEN: -- maximum values for those. The plume starts out just west of where the off-site extraction wells are now and extends out to where the 120-foot aquifer emerges with the 200-foot aquifer. It was about 250 feet, as I recall, something like that out.

SHIRLEY BUFORD: Thank you. Does that answer your question, sir?

JIM ABELOE: Yes, sir.

SHIRLEY BUFORD: Thank you.

Are there any any additional questions?

As Mr. Allen just stated, he's got a copy of the Feasibility Study and other reports here tonight, but they are also located at the information repository at the John Steinbeck Library, including the other community relations materials that have been generated, nine fact sheets and other information that was generated on the Firestone facility. You are welcome to review that material there.

And again, please call us. Any of the presenters that you heard tonight from the Department of Health Services, Firestone, IT, Doctor Wong, the Water Quality Control Board, we're all here to help you and to give information to you about the site.

I would like to thank you for coming out tonight and sitting through the presentations. And please feel free to come and talk to any of the people here. If you have no more questions, we will adjourn the meeting. Thank you.

(Hearing concluded at 8:42 p.m.)

TABLE 2-1

POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Resource Conservation and Recovery Act (RCRA) as amended by Hazardous and Solid Waste Amendments (HSWA) (42 USCA 7401-7642) (40 CFR 260-280)	C	RCRA-related regulations are generally action specific. However, RCRA provides Maximum Concentration Limits (RCRA MCLs) as part of ground-water protection standards (40 CFR 264.94). RCRA MCLs are given for fewer chemicals than the SDWA, although the SDWA MCLs are the basis for RCRA MCLs when regulated.	EPA office of solid waste.
Ground Water Protection (40 CFR 264.90) and monitoring (40 CFR 264.97)	A	Hazardous constituents entering ground water must not exceed concentration limits in the aquifer underlying the waste management area. The ground-water monitoring program must provide a reliable indication of ground-water quality below the waste management area.	EPA office of solid waste.
Safe Drinking Water Act (SDWA) [42 USC 300(f)]	C	Establishes drinking water standards for all sources of public drinking water. California Department of Health Services (DHS) is the primary agency for administration of the SDWA in the state. See state section, Table 2.	DHS
Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16	C	Applicable MCLs are based on Maximum Contaminant Level Goals (MCLGs), best available technology, best treatment techniques, and cost.	DHS in California
Underground Injection Control Regulations (40 CFR Parts 144, 145, 146, and 147)	A	Potentially applicable for alternatives utilizing a ground-water injection option.	DHS in California.

TABLE 2-1
POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Occupational Safety and Health Act (19 CFR 1910)	A	Establishes general safety procedures in the work place. Installed equipment makes it necessary for workers to be engaged in routine activities at the site. Workers may be exposed to dilute organic contaminants from air stripper off gas. OSHA workers exposure levels and general construction safety standards should be considered. OSHA Permissable Exposure Level (PEL) requirements under 19 CFR 1910.120 are applicable to worker exposures during response actions at CERCLA sites, except in states that enforce equivalent or more stringent requirements. California has reinstated a program for nongovernment employee work place exposures with equivalent or more stringent requirements. See discussion in state section.	CAL-OSHA
Executive Order 11988 related to floodplain management 40 CFR 264 and Executive Order 11990 related to Protection of Wetlands, 40 CFR Part 6, Appendix A	L	The current NPDES permitted discharge structure is located in the floodplain and wetlands of the Salinas River. This discharge structure and potential future new structures should avoid adverse effects, minimize potential harm, and preserve resource values in floodplain and wetlands.	RWQCB in California

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[1] Type of ARAR: C-contaminant specific, L-location specific, A-action specific.

TABLE 2-1
POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Clean Water Act (CWA) 33 USCA 1251-1376 40 CFR 100-149		The Clean Water Act requires permitting of effluent discharges under the NPDES permit program and seeks to protect the existing and attainable uses of waters of the U.S.	RWQCB in California
National Pollutant Discharge Elimination System (NPDES) (40 CFR 122-125)	A	NPDES permits contain applicable standards, monitoring requirements, and standard and special conditions for water discharges. Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet the substantive CWA requirements, including discharge limitations, monitoring requirements, and best management practices. Only off-site CERCLA discharge must be permitted. The facility possesses an NPDES permit for discharge to the Salinas River.	RWQCB in California
Water Quality Standards [CWA 402 (a)(1)]	A	Effluent limitations are required to achieve all appropriate State water quality standards. EPA "Policy for the Development of Water Quality-Based Permit Limitations for Toxic Pollutants" (49 FR 9016, March 9, 1984) states that toxic pollutants contained in direct discharges may be controlled beyond Best Control Technology/Best Available Technology (BCT/BAT) equivalents to meet applicable State water quality standards.	Administered by EPA Office of Water.
Clean Air Act (CAA) (42 USCA 7401-7642) (40 CFR 50-69)	A	The Clean Air Act (CAA) is implemented through State programs of the California Air Resources Board (CARB). CARB gives enforcement authority to local air quality management districts. The Monterey Bay Unified Air Pollution Control District (MBUAPCD) enforces air quality for facilities in this area. Activities resulting in emission require a permit to operate with corresponding effluent requirements as for the existing air stripper.	CARB and MBUAPCD See state section.
National Emission Standard for Hazardous Air Pollutants (40 CFR 50-69)	A	National Emission Standards for Hazardous Air Pollutants (NESHAP) are process and industry specific and were promulgated to protect people and the environment. NESHAP standards are currently limited to very few chemicals (40 CFR 61). Benzene is discussed under NESHAPs; however, no emission standards are described (40 CFR 61.110-112).	CARB and MBUAPCD

TABLE 2-2
POTENTIAL STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
California Environmental Quality Act Public Resources Code, Division 13	A	CEQA Law and Guidelines. EIR process and alternatives. Substantial activities requiring State or local government approval, having a potential for adverse impacts may be required if a FONSI is not found by the permitting authority. Environmental and human health impacts are among the criteria utilized in evaluating alternatives in the detailed analysis of the FS/RAP.	Resources Agency Office of Planning and Research
Occupational Health and Safety Act, Labor Code, Section 6300 et seq.	A	Worker safety, responsibilities, and duties of the employer.	Department of Industrial Relations, Division of Industrial Safety.
Chapter 6.6 Safe Drinking Water and Toxics Enforcement Act (Proposition 65)	C	Reproductive toxin levels reporting of hazardous materials releases to local government. Will be required if substances on the State list are being discharged to the environment in levels where an exposure is possible.	DHS

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[1] Type of ARAR: C-contaminant specific, L-location specific, A-action specific.

TABLE 2-2
POTENTIAL STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Regulation XII - New Source Review	A	This regulation sets forth preconstruction review requirements for new or modified stationary sources, to ensure that the operation of such stationary sources does not interfere with progress in attainment of the national ambient air quality standards, without unnecessarily restricting the future economic growth within the district. NAAQS guidelines and total emissions limits are on a case-by-case basis.	MBUAPCD
Pump Test Permit	A	Required for withdrawal and discharge of volatile contaminated ground water when atmospheric release of contaminants is possible.	MBUAPCD
State Drinking Water Act (SDWA), Health and Safety Code, Division 7, Part 1, Chapter 7, Section 4010 et seq. California Code of Regulations, Title 22, Division 4, Chapter 15, Domestic Water Quality and Monitoring	C	SDWA establishes drinking water standards for sources of public drinking water. Federal MCLs are incorporated into State regulations regulations, and in some cases the State may promulgate more stringent State MCLs. The DHS has promulgated MCLs for 12 organics and 2 inorganics in drinking water. Several of the proposed MCLs are the same as or more stringent than the current nonpromulgated DHS ALs. Under SDWA, as amended by "AB 1803," sampling and analysis of drinking water sources are required. Upon review of the results of initial sampling, a monitoring program is established by DHS. In the event of violation of DHS action levels for drinking water, public notification may be required.	DHS is responsible for administering the State SDWA, which includes the "AB 1803" monitoring program.
Porter-Cologne Water Quality Act Water Code, Division 7, Section 13000 et seq., CCR Title 23, Chapter 3, Subchapter 9 and Subchapter 15, 1050-2836	A	Similar to the Federal CWA, the Act and its associated regulations apply to protection of waters of the State. An NPDES permit is required for off-site discharges, whereas, only substantive requirements are required for on-site discharges. Porter-Cologne delegates standard setting authority to the RWQCBs. RWQCB will not dictate specific treatment alternatives but will require that the alternative meet minimum action levels and perform at a level near the Best Available Technology (BAT) for the chosen alternative. The RWQCB is responsible for establishing NPDES substantive and administrative requirements for permitting at levels sufficiently protective of the waters of the State. RWQCB emission standards are set on a case-by-case basis and apply to treated wastewater, storm water runoff, etc. Waste discharge reports and requirements are also specified.	RWQCB

TABLE 2-2
POTENTIAL STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Rule 402 - Nuisance (including odors)	A	Prohibits the discharge of any material (including odorous compounds) that may cause injury, detriment, nuisance, or annoyance to the public, businesses, or property, or endanger human health, comfort, repose, or safety. This rule would be used for enforcement in odor problem situations.	MBUAPCD
Rule 403 - Fugitive Dust	A	Limits on-site activities so that the concentrations of fugitive dust at the property line shall not be visible and the downwind particulate concentration shall not be more than 100 micrograms per cubic meter, averaged over 5 hours, above the upwind particulate concentration. The rule also requires taking every reasonable precaution to minimize fugitive dust. May be applicable for construction activities.	MBUAPCD
Regulation IX - Standards of Performance for New Stationary Sources	A	Implements the provisions of Part 60, Chapter I; Title 40 of the Code of Federal Regulations (CFR) under the supervision of MBUAPCD Executive Officer.	MBUAPCD
Regulation X - National Emission Standards for Hazardous Air Pollutants	A, C	Implements the provisions of Part 61, Chapter I, Title 40, of the Code of Federal Regulations (CFR) under the supervision of MBUAPCD Executive Officer, if contaminants identified at site are listed.	MBUAPCD
Rule 1167 - Air Stripping Operations (Regulation XI - Source-Specific Standards)	A	The rule is designed to reduce volatile organic compound (VOC) emissions from new and existing air stripping equipment used for the treatment of contaminated water. The rule requires that all exhaust gases from air stripping equipment shall be vented through a control device or process that will reduce the total VOC emissions to a level that is at least 90 percent of the previous emissions on a mass basis. However, the rule exempts from this specific requirement air stripping equipment that have total VOC emissions of 1 pound per day, or less. Recordkeeping of water and air stream analysis of VOC concentration is required for all facilities. These requirements are reflected in the conditions of the existing air permit.	MBUAPCD

TABLE 2-2
POTENTIAL STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Closure and Postclosure of Interim Status and Permitted Facilities (Title 22, 67210-67220)	A	The facility shall be closed in a manner that minimizes the need for further maintenance (67211[a]) and controls, minimizes, or eliminates postclosure escape of hazardous waste, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or the atmosphere (67211[b]).	DHS
Closure and Postclosure of Interim Status and Permitted Facilities (continued) (Title 22, 67210-67220)	A	Contamination at the Firestone Site was identified during closure activities of a permitted facility. Thus, DHS is the lead agency for this FS/RAP, although the site and adjacent contaminated ground water are currently being remediated and the facility has been formally closed and the contamination source removed. Postclosure monitoring requirements must still be met.	DHS
Hazardous Waste Hauler Registration (Title 22, 66420-66465) and Requirements for Transporters of Hazardous Waste (Title 22, 66530-66564)	A	Hazardous waste must be transported by a hauler registered by the state.	DHS
Mulford-Carrell Air Resources Act, Health and Safety Code, Division 26, Section 39000 et seq. 17 CAC Part III, Chapter 1, Section 60000 et seq.	A, C	The State counterpart to the Federal CAA, Mulford-Carrell establishes the California Air Resources Board (CARB) and local Air Quality Management Districts (AQMDs). The CARB and AQMDs are given responsibility for protection of air quality in the state. They must also develop control measures for reducing emissions of the CARB-identified toxic air contaminants. Permitting authority is delegated in this act. The Firestone facility and associated remediation activities are subject to permit requirements issued under this authority. Allocation of allowable emissions are on an air basin specific basis.	CARB and (MBUAPCD)
Monterey Bay Unified Air Pollution Control District (MBUAPCD) Rules and Regulations		The following sections and regulations from MBUAPCD may apply to a water-treatment system, should air stripping be used as a technology.	MBUAPCD
Regulation IV - Prohibitionary Rul.			

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POTENTIAL STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Hazardous Waste Control Act (Health and Safety Code, Section 25100-25395) as administered by the Department of Health Services (DHS) under the California Code of Regulations, Title 22, Chapter 30; Minimum Standards for Management of Hazardous and Extremely Hazardous wastes.	A	HWCA has many elements that are intended to control hazardous wastes from their point of generation through accumulation, transportation, treatment, storage, and ultimate disposal. It is implemented largely through regulations under CCR, Title 22, Division 4, Chapter 30. Section 66300 of Chapter 30 provides no RCRA-type exemption for CERCLA sites.	DHS
Criteria for Identifying Hazardous Wastes (Title 22, 66693-66746)	C	Tests for identifying hazardous characteristics are described in Title 22, Article 11, Sections 66693-66746. If a waste is either listed or tested and found hazardous, then management must comply with the hazardous waste requirements under Title 22. While these standards are not treatment or disposal limits, the resulting classification as hazardous waste results in efforts to meet the standard, thereby making hazardous designation methods a form of treatment standard.	DHS
Requirements for Generators of Hazardous Waste (Title 22, 66470-66515)	A	An owner or operator who initiates a shipment of hazardous waste from a Transport, Storage, or Disposal (TSD) facility shall comply with the generator standards established under Article 6 (66470-66515), Title 22 of CAC* (66470[d]). These standards include keeping of manifests (66481), submission of manifest to DHS within 30 days of shipment (66484[f]), preparation of a biennial report (66493[a]), and a maximum 90-day accumulation time (66508[a]).	DHS

TABLE 2-3

POTENTIAL OTHER FEDERAL CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED (TBC)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Federal Criteria, Advisories, and Procedures			
Health Effects Assessments (HEAs) and Proposed HEAs ("Health Effects Assessment for [Specific Chemical]"), ECAO, USEPA, 1985	C	Provides health effects assessments for various compounds.	EPA
Reference Dose (RfDs), ("Verified Reference Doses of USEPA," ECAO-CIN-475, January 1986)	C	Provides health-based reference doses for various compounds.	EPA
Carcinogen Potency Factors (CPFs), (Table 11, "Health Assessment Document for Tetrachloroethylene (Perchloroethylene)," USEPA, OHEA/600B82/005F, July 1985)	C	Provides carcinogenic potency factors for PCE.	EPA
Pesticide and food additive tolerances and action levels. Note: Germane portions of tolerances and action levels may be pertinent and therefore are to be considered in certain situations	C	Provides pesticide and food additive tolerances and action levels.	EPA
Federal sole source aquifer requirements (52 FR 6873, March 5, 1987)	A	Provides sole-source aquifer requirements.	EPA
EPA's Ground Water Protection Strategy	A	Presents EPA's policy on protection of ground water.	EPA

TABLE 2-3
POTENTIAL OTHER FEDERAL CRITERIA, ADVISORIES AND GUIDANCE TO BE CONSIDERED (TB
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Guidance on Remedial Actions for Contaminated Ground Water at Superfund sites (Draft, October 1986) establishes criteria for the use of background concentrations and ACLs	A	Provides guidance on key decisions in the development, evaluation, and selection of ground-water remedial actions.	DHS
Superfund Public Health Evaluation Manual	C	Outlines health-based risk assessment.	EPA
EPA Health Advisories for Drinking Water	C	These advisories are nonpromulgated concentrations of drinking water contaminants for organic and inorganic chemicals. The advisories are levels at which adverse health effects would not be anticipated to occur over specific exposure durations. For non-carcinogens, advisories have been developed for difference exposure durations. Lifetime exposure advisories were used for the carcinogens.	EPA Office of Drinking Water
SDWA Maximum Contaminant Level Goals (MCLG)	C	MCLGs are health-based standards which do not consider available technology or cost. They may be more protective than MCLs.	DHS
USEPA RCRA Guidance Documents			
Interim Final Alternate Concentration Limits. Guidance Part I: ACL Policy and Information Requirements (July 1987)	C	Presents EPA's ACL policy.	EPA
Technical Resource Documents (TRDs).	A	Presents guidance on well construction and monitoring along with other technical areas.	EPA
RCRA Ground-Water Monitoring Technical Enforcement Guidance Document	A	Presents components of ground-water monitoring systems.	EPA
USEPA Office of Water Guidance Documents			
Water-Related Environmental Fate of 129 Priority Pollutants (1979)	C	Summarizes environmental fate of chemicals in water.	EPA

TABLE 2-3
POTENTIAL OTHER FEDERAL CRITERIA, ADVISORIES AND GUIDANCE TO BE CONSIDERED (TBC)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Quality Criteria for Water 1986 Clean Water Act Water Quality Criteria for Protection of Human Health and Fresh Water Aquatic Life 51 FR 43666	C	Water Quality Criteria (WQC) established under Section 304 of CWA (51 FR 43665), are based on effects of human health and aquatic life that do not reflect technological or economic considerations. CWA WQCs are applicable to water discharges to surface or ground water. These substantive criteria would apply to wastewater discharges to the Salinas River.	RWQCB
Technical Support Document for Water Quality Based Toxics Control	A	Elaborates on water-quality-based toxics control.	RWQCB
Developing Requirements for Direct and Indirect Discharges of CERCLA Wastewater (1987)	A	Explains development of wastewater discharges.	RWQCB
NPDES Guidance Documents -	A	Presents guidance relative to NPDES procedures.	RWQCB
NPDES Best Management Practices Guidance Manual (June 1981)	A	Presents guidance on NPDES BMP.	
Ground Water/UIC Guidance Documents - Corrective Action Requirements Ground Water Protection Strategy (August 1984)	A	Presents guidance relative to ground-water protection.	RWQCB
Clean Water Act Guidance Documents	A	Presents guidance relative to CWA.	RWQCB
EPA IRIS Cancer Risk Information	C	EPA IRIS cancer risk information represents the most current, peer-reviewed chemical concentrations in water producing risk levels. The 10^{-6} risk level was used for the risk assessment in this FS. The IRIS values are more current than the Clean Water Human Health Criteria for Drinking Water.	EPA
Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (Draft)	A	Presents CERCLA procedures.	EPA

TABLE 2-3
POTENTIAL OTHER FEDERAL CRITERIA, ADVISORIES AND GUIDANCE TO BE CONSIDERED (TBC)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Guidance on Preparing Superfund Decision Document: The Proposed Plan and Record of Decision (Draft)	A	Presents guidance on preparing ROD.	EPA
Standard Operating Safety Guides	A	Presents safety procedures for operations.	Cal-OSHA

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[1] Type of TBC: C-contaminant specific, L-location specific, A-action specific.

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POTENTIAL OTHER STATE AND LOCAL CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED (TBC)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
Department of Health Services Decision Tree, Revised December 1986	A, C	Provides guidance on development of site-specific cleanup levels and evaluation of remedial action alternatives.	DHS
Water Quality Control Plans of the State Water Resources Control Board and the Regional Water Quality Control Board	L	Water Quality and Basin Plans. Use attainability studies and the current water quality of surface waters are used in determining allowable discharges to surface water bodies under NPDES permits.	State Water Resources Control Board; RWQCB
RWQCB Water Quality Control Plan Effluent Limitations	L, A, C	The Clean Water Act and Porter-Cologne Water Quality Act require regional water quality control boards to develop water quality control plans. Effluent limitations are specified in River Basin Water Quality Control Plan. These limitations are not promulgated, but are considered when permitting wastewater discharges to surface water bodies.	RWQCB
DHS Drinking Water Action Levels (ALs)	C	DHS action levels are specified for some of the organic contaminants that have been identified in ground water. These levels in some cases are available for contaminants that do not have MCLs. DHS action levels are recommended drinking water levels and are not promulgated, but could be used as policy or guidance. Water purveyors in California will generally take action if the DHS notifies them of contaminants exceeding ALs. ALs are not promulgated, but are used as DHS policy. These are drinking water standards developed by the DHS and in practice must be met to comply with DHS requirements.	DHS. ALs are also used by other agencies as the basis for effluent and disposal limitations.

TABLE 2-4
POTENTIAL OTHER STATE AND LOCAL CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED (TBC)
(Continued)

REQUIREMENTS	TYPE[1]	SUMMARY	ADMINISTERING AGENCY
DHS Applied Action Levels (AALs)	C	Applied action levels are exposure limits that are pollutant- and receptor-specific and used as a starting point for establishing cleanup levels. If the AALs are exceeded, then actions should be taken to clean up contaminants down to these levels. In some cases, cleanup may be allowed by the DHS to be greater than the AALs. However, justification must be given for doing so, and the DHS must approve the modified cleanup levels. Water treatment values should meet AAL standards for water discharges and human receptors (i.e., drinking water). Also, AALs are available for the air to human pathway. Applied action levels are not promulgated, but could be used as policy or guidance.	Applied by DHS on a site-specific basis.
Central Valley RWQCB Designated Level Methodology for Waste Classification and Cleanup Level Determination (October 1986)	C	This guidance document is in the tentative stage of development for use in the classification and subsequent disposal method of both hazardous and non-hazardous wastes. The method is still site specific but generic; conservative classification levels can be approximated. The Designated Levels are to be considered criteria.	RWQCB

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[1] Type of TBD: C-contaminant specific, L-location specific, A-action specific.

TABLE 2-5

ORGANIC CONSTITUENTS

WATER QUALITY GOALS - HUMAN HEALTH AND WELFARE[1]

ORGANIC CONSTITUENTS	STATE AND EPA DRINKING WATER STANDARDS MAXIMUM CONTAMINANT LEVELS (MCLS)			DHS DRINKING WATER ACTION LEVELS		DHS APPLIED ACTION LEVELS[2]	NONCANCER HEALTH ADVISORIES OR SUGGESTED NO-ADVERSE-RESPONSE LEVELS (SNARLs)		ONE IN ONE MILLION INCREMENTAL CANCER RISK LEVEL			EPA -- NATIONAL AMBIENT WATER QUALITY CRITERIA BASED ON NONCANCER PUBLIC HEALTH
	PRIMARY MCL	MCL GOAL--EPA	STATE	TOXICITY	TASTE & ODOR	WATER	EPA	NAS	EPA -- NATIONAL AMBIENT WATER QUALITY CRITERIA	EPA HEALTH OR WATER QUALITY ADVISORIES	NATIONAL ACADEMY OF SCIENCES (NAS)	
	ug/l	ug/l	(ug/l)	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
1,1-Dichloroethylene	7	7	6				70[4]	100				
1,1-Dichloroethane				5								
1,2-Dichloroethane	5	Zero	0.5				740[4]		0.94	0.95	0.71	
Benzene	5	Zero	1			0.7	70		0.66	0.68		
Ethylbenzene	700[3]	700[3]	680		29	680	680[4]					1,400
Tetrachloroethylene	5[3]	Zero[3]	5	5			19,400[4]		0.8	0.67	3.6	
Toluene	2,000[3]	2,000[3]		100		100	12,000[4]	340				14,300
1,1,1-Trichloroethane	200	200	200			200	200[4]	3,800			17[5]	18,400
Trichloroethylene	5	Zero	5				75		2.7	4.5	1.5[5]	
Xylene(s)	10,000[3]	10,000[3]	1,750			620	440[4]					

[1] Adapted from California Regional Water Quality Control Board, Central Valley Region, 1987, Appendix III, "The Designated Level Methodology for Waste Classification and Cleanup Level Determination," prepared by Jon. B. Marshack, revised September 14, 1987, except for AAL's (see Note 6).

[2] DHS, TSCD, December 2, 1987, human receptors; AAL water is SEB Action Level.

[3] Proposed, updated as of May 22, 1989 Federal Register, pg. 22064.

[4] Draft/Tentative.

[5] Based on limited evidence.

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TABLE 3-1

FLOWRATES FOR EXTRACTION ALTERNATIVES
INTERMEDIATE AQUIFER
FORMER FIRESTONE FACILITY

	EXTRACTION ALTERNATIVE					
WELL	1	2	3	4	5	6
IT-IE1	-	-	-	-	150	150
IT-IE2	150	-	150	-	150	150
IT-IE3	150	-	-	-	-	150
IT-IE4	150	150	150	100	150	150
IT-IE5	100	-	-	-	-	100
IT-IE6	-	-	-	150	-	-
IT-IE7	-	-	-	150	-	-
IT-IE8	150	150	-	-	150	-
IT-IE9	-	150	150	150	-	-
IT-IE10	-	150	150	150	-	-

NOTE: Flowrates given in gpm.

Flowrates shown were used in the tradeoff studies between various extraction alternatives. Actual flowrates to be used in remediation will be established by the Site Manager based on the monitoring data for the recommended remedial alternative, Alternative D, the combined flowrates will not exceed 650 gpm, the current treatment plant capacity.

TABLE 4-1

EXAMINATION OF ALTERNATIVES VERSUS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOW RATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Contaminant-specific -USEPA Safe Drinking Water Act .Maximum Contaminant Levels	Residual risk of chemicals in soil after soil removal is deemed acceptable for all alternatives.				
-CDHS State Drinking Water Act Drinking Water Action Levels -USEPA Ambient Water Quality -USEPA Health or Water Quality advisories	Allowing only natural mechanisms to meet various chemical-specific ARARs for ground-water protection will be time-consuming.	Action levels for all chemicals of interest in the shallow aquifer will be met. The potential for contamination of deep aquifers due to lack of remediation in the intermediate zone is high.	Action levels will be met for all ground water chemicals of interest in the shallow and 120-foot intermediate zone aquifers. Further contamination of the deep aquifers is not expected due to the cleanup of the ground water in the contributing intermediate and shallow zones.		
Action-specific -USEPA Clean Water Act, National Pollutant Discharge Elimination System and Water Quality Standards -CRWQCB, Porter-Cologne Water Quality Act, NPDES and Water Quality Standards	Not applicable	Utilization of the existing treatment plant will not result in any violations of the existing permit requirements with regard to discharge quantity or quality.	Potentially high flow rates over 1,000 gpm envisioned under this alternative may require modification of the 1,000 gpm flow limitations contained in the existing NPDES permit. Water quality requirements are not expected to be exceeded, although start-up and debugging of a new air stripper may require special water handling requirements to assure adequate treatment.	Utilization of the existing treatment plant will not result in any violations of the existing permit requirements with regard to discharge quantity or quality.	Utilization of the existing treatment plant will not result in any violations of the existing permit requirements with regard to discharge quantity or quality.
-USEPA, Clean Air Act -CARB, Mulford-Carrell Air Resources Act -MBUAPCD, Rules and Regulations	Not applicable	The existing permit to operate provides limitation on the rate of treatment by the air stripper, total hydrocarbon emissions and emission limitations for specific contaminants. Operation of the system will be performed in compliance with the existing permit limitations and requirements.	Installation of a new air stripper would require modification of the existing flow rate limitations. The MBUAPCD may limit overall emissions from both strippers to the existing specific contaminant quantities. Monitoring both units separately may be required, as well as detailed start-up monitoring for the new units. Total emissions may exceed 75 percent of the permitted amount,	The existing permit to operate provides limitation on the rate of treatment by the air stripper, total hydrocarbon emissions and emission limitations for specific contaminants. Operation of the system will be performed in compliance with the existing permit limitations and requirements.	The existing permit to operate provides limitation on the rate of treatment by the air stripper, total hydrocarbon emissions and emission limitations for specific contaminants. Operation of the system will be performed in compliance with the existing permit limitations and requirements.

TABLE 4-1
EXAMINATION OF ALTERNATIVES VERSUS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
(CONTINUED)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOW RATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
-USEPA, Clean Air Act -CARB, Act Mulford-Carrell Air Resources -MBUAPCD, Rules and Regulation (continued)			potentially requiring more frequent monitoring. Technical difficulties achieving the requirements could occur if air district was inflexible regarding increasing allowable emissions.		
-MBUAPCD, Standards of Performance for New Stationary Sources, New Sources Review	Not applicable	Not applicable	Satisfaction of these regulations would be required for development and installation of a new air stripper. Includes preconstruction review requirements prior to issuance of a permit to construct. Potentially high expense and lag time relative to the project scope for compliance.	Not applicable	Not applicable
-MBUAPCD, Pump Test Permit	Not applicable	Not applicable	A pump test permit would be required for testing of new wells where discharge of volatile contaminated ground water with potential for atmospheric release would occur, such as, in well development. Compliance problems are not anticipated, as the levels of contamination are low and permits have been issued for these purposes in the past.		
-OSHA and Cal-OSHA General Construction Standards	General construction standards will be adhered to for all construction and demolition activities undertaken per the site Health and Safety Plan.				
-OSHA and Cal-OSHA permissible exposure levels	Not applicable	Full compliance with these statues will be provided per the existing site health and safety plan. Worker safety is assessed in the risk assessment by low levels of worker risk.			
			Hypothetical worker risk will be somewhat higher in this scenario due to increased emissions, but should be within the PEL levels.		

TABLE 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Short-Term Effectiveness Time until protection is achieved	Shallow and intermediate zone aquifers expected to reach clean-up levels by Winter 1998/99.	Shallow aquifer is expected to be remediated by Winter 1991/92.	Remediation of the shallow and intermediate zone aquifers is expected to be completed by Winter 1991/92.	Remediation of the shallow and intermediate zone aquifers is expected to be completed by Fall 1990.	Remediation of the shallow and intermediate zone aquifers is expected to be completed by Winter 1993/94.
	Protection consists of lack of sensitive receptors and checking by monitoring to determine plume movement and dispersion. Minimum time required for monitoring is 5 years.	Protection for intermediate zone consists of lack of sensitive receptors and assurance by monitoring to determine plume movement and dispersion. Minimum time for monitoring is 5 years.	Remediation of the shallow and intermediate zone aquifers is expected to protect the deep aquifers from future degradation.	Same as Alternative C.	Same as Alternative C.
	Reliance on natural mechanisms and aeration through spray irrigation will require a long time to remediate the shallow and intermediate zone aquifers and may result in degradation of the deep aquifer.	Reliance on natural mechanisms and aeration through spray irrigation will require a long time to remediate the intermediate zone aquifer and may result in degradation of the deep aquifer.	Concentrations of chemicals in the deep aquifer are reduced by pumping from agricultural wells.	Same as Alternative C.	Same as Alternative C.
Protection of community during remedial actions.	Remedial actions under these alternatives may not be considered complete until monitoring assures protection. If protection does not occur, the potential for contamination of the deep aquifer, used for irritation and domestic water supply, is high.	Protection of community provided by air emissions limits in MBUAPCD permit and by surface-water discharge limits in NPDES permit.	Same as Alternative B.	Same as Alternative B.	Same as Alternative B.

Table 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Protection of workers during remedial actions	Not applicable to site workers - direct remediation will be terminated.	Site worker exposures are considered negligible considering the emission rates, combination of factors required for exposure, and duration of expected remediation activities. Compliance with standard operating procedure and OSHA regulations will protect workers during remedial activities.	Same as Alternative B.	Same as Alternative B.	Same as Alternative B.
	Agricultural worker exposure will potentially be higher because of the longer duration, although the Risk Assessment concluded this risk was minimal.	Duration of exposure is less than Alternative A.	Duration of exposure is only slightly longer than Alternative D.	Duration of exposure is least of all alternatives.	Duration of exposure is int between Alternatives B and
Environmental impacts	Flow of contaminants from the shallow and intermediate to deep aquifers may occur. Furrow irrigation of nontreated ground water will increase the potential for low level soil contamination.	Flow of contaminants from the intermediate zone to the deeper aquifers may occur. Furrow irrigation of nontreated waters will increase the potential for low level soil contamination. NPDES water discharge and air permit emission limitations protect against adverse environmental impacts.	High water discharge flow rates exceed current NPDES permit requirements. Air permit flow rate limitations may be exceeded.	NPDES water discharge and air permit emission limitations protect against adverse environmental impacts.	NPDES water discharge and a emission limitations prote adverse environmental impa

Table 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Long-Term Effectiveness and Performance Magnitude	High relative residual risk, although risk assessment showed this risk was generally acceptable. Lack of remediation may allow downward migration of contaminated water to deep aquifers.	Moderate residual risk. Lack of remediation of intermediate zone may allow downward migration of contaminated water from this zone to deep aquifers.	Low residual risk - remediation of the shallow and intermediate zones is expected to minimize the potential for contamination of the deep aquifers and associated risks.	Same as Alternative C.	Same as Alternative C.
Adequacy and reliability of controls.	Long-term monitoring will be required to monitor natural attenuation of contamination and maintenance of ground water quality.	Long-term monitoring will be required to monitor that migration of water from the intermediate zone will not affect deeper ground water.	Monitoring of ground-water wells will continue throughout remediation and for two years following achievement of the cleanup levels. Treatment plant monitoring will continue during operation.	Same as Alternative C.	Same as Alternative C.
	No treatment plant operations for Alternative A.	The existing treatment system has been operated reliably since Spring 1986 and is expected to operate reliably during the remedial action. No problems are expected in meeting permit requirements.	Installation of a new air stripper will require a period of startup and additional controls.	The existing treatment system has been operated reliably since Spring 1986 and is expected to operate reliably during the remedial action. No problems are expected in meeting permit requirements.	Same as Alternative D.

Table 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Reduction of Toxicity, Mobility, or Volume Treatment process and remedy -Amount of hazardous material destroyed -Reduction in toxicity, mobility, and volume -Irreversibility of treatment -Type and quantity of treatment residual	Toxicity is reduced by natural attenuation. Mobility is not affected. Volume of affected area is increased although at a reduced concentration.	Air stripping and/or carbon adsorption reduce toxicity, mobility, and volume of chemicals in affected ground water.	Air stripping and carbon adsorption reduce toxicity, mobility, and volume of chemicals in affected ground water.	Same as Alternative C.	Same as Alternative C.
	Source, vadose zone, and ground-water aquifers will not be actively treated. Aeration and natural mechanisms will be relied on to reduce toxicity. The contaminants will be dispersed irreversibly throughout the ground-water plume.	Contaminants in the shallow zone ground water are actively remediated. Source, vadose zone, and intermediate and deep aquifer contamination will not be actively treated. For remediation of the deep and intermediate aquifers, aeration through irrigation and natural mechanisms will be relied on to reduce toxicity. The contaminants will be dispersed irreversibly throughout the ground water plume.	Contaminants in the shallow and intermediate zone ground water aquifers are addressed. Aquifer remediation of the shallow and intermediate zone minimize the potential for further contamination of the deep aquifers. Source, vadose zone, and deep aquifer contamination will not be treated other than by the agricultural well pumping.	Same as Alternative C.	Same as Alternative C.
			Contaminants removed by the air stripper will be emitted to the atmosphere. Contaminants removed by the carbon unit will be sent to a recycler for regeneration. Small amounts of chemicals may be discharged to the Salinas River.	Same as Alternative C.	Same as Alternative C.

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TABLE 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Technical Feasibility					
-Ability to construct technology	No new construction.	No new construction.	The ability to construct new wells is dependent on the ability to obtain easements on private property and connect them to the existing system.	Same as Alternative C.	Same as Alternative C.
-Reliability of technology	Reliance on natural mechanisms and irrigation for remediation is slow.	The existing treatment system has been operated since Spring 1986 with a high degree of reliability. Technical problems with the existing system are not expected.	Same as Alternative B.	Same as Alternative B.	Same as Alternative B.
-Ease of undertaking additional remedial action, if necessary.	Prior to dismantling the treatment system, maintaining the treatment plant in standby mode for 2 years will allow quick restart of the system, should the need arise.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Table 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
-Monitoring considerations	Existing monitoring network of ground-water wells will be used.	Existing monitoring network of ground-water wells and treatment plant sampling points will be used.	In addition to existing system, monitoring will be added at new wells and at new air stripper.	In addition to existing system, monitoring will be added at new wells.	Same as Alternative D.
Administrative Feasibility					
-Coordination with other agencies	No permits required,	No new permits required.	NPDES and MBUAPCD permit modifications would be required for installation of a new air stripper.	No new permits required.	No new permits required.
Availability of Services and Materials	No new services, materials or personnel are required.	Same as Alternative A.	The availability of resources to develop new wells into the intermediate zone is only expected to be limited by the availability of land, easements, and right of ways, etc., not by services or materials.	Same as Alternative C.	Same as Alternative C.
Cost, Net Present Worth, $1,000					
-3 percent discount rate	1,525	3,186	5,905	1,829	3,444
-5 percent discount rate	1,387	2,990	5,722	1,792	3,111
-10 percent discount rate	1,116	2,598	5,309	1,708	3,017

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TABLE 4-2

SUMMARY OF DETAILED ANALYSIS OF REMEDIATION ALTERNATIVES
(Continued)

ANALYSIS FACTORS	ALTERNATIVE A - NO ACTION	ALTERNATIVE B - REMEDIATE SHALLOW AQUIFER ONLY	ALTERNATIVE C - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, HIGH FLOWRATE, PLANT EXPANSION, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE D - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, FIVE NEW INTERMEDIATE ZONE WELLS	ALTERNATIVE E - REMEDIATE SHALLOW AND INTERMEDIATE AQUIFERS, EXISTING PLANT, TWO NEW INTERMEDIATE ZONE WELLS
Compliance with ARARs Compliance with contaminant-specific areas	Monitoring will continue for 2 years after the contaminant-specific ARARs, including health-based concentrations, are achieved.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
-Compliance with action-specific ARARs	Not applicable.	Complies with action-specific ARAR, through existing NDPES permit and MBUAPCD permit.	Treatment plant modifications to accommodate high flow rate will require NDPES permit modifications of allowable flow rates and MBUAPCD permit to operate.	Complies with action-specific ARARs through existing NDPES permit and MBUAPCD permit.	Same as Alternative D.
Overall Protection of Human Health and Environment					
-Human health and environmental protection through risk elimination reduction or control	Risk assessment shows current risk is at acceptable level. This alternative has long duration of exposure.	Same as Alternative A, except that duration of exposure in shallow aquifer is less.	Risk assessment shows current risk is at acceptable level. This alternative has short duration of exposure.	Provides the best mix of protection of all environmental media and human health by concentrating on areas of high contamination first.	Somewhat lower potential for risk reduction than Alternatives C and due to lower contaminant capture capabilities of a two well intermediate zone extraction system (compared to five well systems).
			Remediation of contaminated ground water in the shallow and intermediate zone aquifers will protect the deep aquifers from further contamination and reduce human health and environmental risk.	Same as Alternative C.	Same as Alternative C.

May 25, 1989

Table 4-3
COST COMPARISON OF ASSEMBLED ALTERNATIVES
FIRESTONE
($1,000's)

Alternative	Short-term Capital Cost	Incremental Long-term O&M Cost	Net Present Worth at Discount Rate 3 Percent	5 Percent	10 Percent
A: Pumping rate = 0 gpm No Action. 10 years	-	Varies	1,525	1,387	1,116
B: Pump Incrementally 500 gpm to 0 12.83 years	-	Varies	3,186	2,990	2,588
C: Pump Incrementally 1150 gpm to 0 Expand plant + five wells. 4.67	510	Varies	5,905	5,722	5,308
D: Pump Incrementally 650 gpm to 0 Add five wells, 3.42 years	275	Varies	1,829	1,792	1,708
E: Pump Incrementally 500 gpm to 0 Add two wells. 6.67 years	200	Varies	3,444	3,311	3,017

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Table 4-4
COST SUMMARY OF ALTERNATIVE A
NO ACTION - PUMPING RATE = 0
10 Years (April '89 to April '00)
FIRESTONE

Cost Items		Annual Estimated Costs
Construction Costs		
All capital costs are "sunk" and not a part of this evaluation.		
Monitoring (O & M)		
10 Years Monitoring	$14,000 /MO. :	$168,000
Total Plant Operation (O & M)		
2 Years Standby Only	$4,000 /MO. :	$48,000
ANNUALIZED COST O & M		
NET PRESENT WORTH OF ANNUALIZED O & M COST		
(Uniform Series Present Worth for 10 Yrs.)		
3%	8.530 factor	$1,433,074
5%	7.722 factor	$1,297,251
10%	6.145 factor	$1,032,287
(Uniform Series Present Worth for 2 Yrs.)		
3%	1.913 factor	$91,847
5%	1.859 factor	$89,252
10%	1.736 factor	$83,306
TOTAL PRESENT WORTH OF ANNUALIZED O & M COST ALTERNATIVE A		
At 3 percent		$1,524,921
At 5 percent		$1,386,503
At 10 percent		$1,115,593

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Table 4-5
COST SUMMARY OF ALTERNATIVE B
PUMP INCREMENTALLY - PUMPING RATE : 500gpm to 0
12.83 Years (April '89 to Jan. '02)
FIRESTONE

Cost Items			Annual Estimated Costs
April '89 to Jan '92 2.75 Years Duration	Pumping rate @ 500gpm End pump & treatment Jan '92		
Construction Costs All capital costs are "sunk" and not a part of this evaluation.			
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M) Includes air stripper & carbon treatment		$35,200 /MO.	
		$53,200 /MO. =	$638,400
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 2.75 Yrs.)			
3%	2.602 factor		$1,661,344
5%	2.511 factor		$1,603,165
10%	2.306 factor		$1,471,948
January '92 to January '02 10 Years Duration	Pumping rate @ 0 gpm		
Monitoring (O & M)		$14,000 /MO. =	$168,000
Total Plant Operation (O & M) For two years	On standby	$4,000 /MO. =	$48,000
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 2 Yrs.)			
3%	1.913 factor		$91,847
5%	1.859 factor		$89,252
10%	1.736 factor		$83,306
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 10 Yrs.)			
3%	8.530 factor		$1,433,074
5%	7.722 factor		$1,297,251
10%	6.145 factor		$1,032,287
TOTAL PRESENT WORTH OF ANNUALIZED O & M COST ALTERNATIVE B			
At 3 percent			$3,196,264
At 5 percent			$2,989,668
At 10 percent			$2,587,541

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Table 4-6
COST SUMMARY OF ALTERNATIVE C
PUMP INCREMENTALLY, EXPAND PLANT; ADD FIVE WELLS - PUMPING RATE : 1150 gpm to 0
4.67 Years (April '89 to January '94)
FIRESTONE

Cost Items			Annual Estimated Costs
April '89 to January '92	Pumping rate @ 500 gpm		
2.75 years Duration	End pump & treat 01/92		
Construction Costs All capital costs are "sunk" and not a part of this evaluation.			
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. :	$1,755,600
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 2.75 Yrs.)			
3%	2.602 factor		$4,568,696
5%	2.511 factor		$4,408,704
10%	2.306 factor		$4,047,856
November '89 to October '90	Pumping rate @ 650 gpm		
1 year Duration	Pump and treat 120' wells		
Monitoring (O & M)	(included above)	$0 /MO.	
Total Plant Operation (O & M)	(included above)	$0 /MO.	
		$0 /MO. :	$0
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 1 Yrs.)			
3%	0.971 factor		$0
5%	0.952 factor		$0
10%	0.909 factor		$0

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Table 4-6 (cont.)
COST SUMMARY (CONTINUED) OF ALTERNATIVE C
PUMP INCREMENTALLY, EXPAND PLANT; ADD FIVE WELLS - PUMPING RATE : 1150 gpm to 0
4.67 Years (April '89 to January '94)
FIRESTONE

Cost Items			Annual Estimated Costs
January '92 to January '94 2 years Duration	Pumping rate 0 gpm Treatment plant on standby		
Monitoring (O & M)		$14,000 /MO.	
Total Plant Operation (O & M)	(on standby)	$4,000 /MO.	
		$18,000 /MO. :	$432,000
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 2 Yrs.)			
3%	1.913 factor		$826,619
5%	1.859 factor		$803,265
10%	1.736 factor		$749,752
June '89 to October '89 Construction Cost	Expand plant, add five new wells and pipline		
	Wells and pipeline		$275,000
	Plant expansion		$235,000
	Total Construction Cost		$510,000
TOTAL PRESENT WORTH OF ANNUALIZED O & M AND CAPITAL COSTS ALTERNATIVE C			
At 3 percent			$5,905,314
At 5 percent			$5,721,970
At 10 percent			$5,307,608

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Table 4-7
COST SUMMARY OF ALTERNATIVE D
PUMP INCREMENTALLY, ADD FIVE WELLS - PUMPING RATE = 650 gpm to 0
3.42 Years (April '89 to September '92)
FIRESTONE

Cost Items			Annual Estimated Costs
April '89 to July '89	Pumping rate 500 gpm		
0.25 years Duration	Pump and treat Onsite wells		
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. =	$159,600
NET PRESENT WORTH OF ANNUALIZED O & M COST			
(Uniform Series Present Worth for 0.25 Yrs.)			
3%	0.245 factor		$39,168
5%	0.242 factor		$38,698
10%	0.235 factor		$37,579
July '89 to November '89	Pumping rate 500 gpm		
0.33 years Duration	Pump and treat Offsite wells		
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. =	$210,672
NET PRESENT WORTH OF ANNUALIZED O & M COST			
(Uniform Series Present Worth for 0.33 Yrs.)			
3%	0.324 factor		$68,166
5%	0.319 factor		$67,296
10%	0.310 factor		$65,230

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Table 4-7 (cont.)
COST SUMMARY (CONTINUED) OF ALTERNATIVE D
PUMP INCREMENTALLY, ADD FIVE WELLS - PUMPING RATE : 650 gpm to 0
3.42 Years (April '89 to September '92)
FIRESTONE

Cost Items			Annual Estimated Costs
November '89 to October '90	Pumping rate 650 gpm		
1 year Duration	Pump and treat 120' wells		
	End pump & treat October '90		
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. =	$638,400
NET PRESENT WORTH OF ANNUALIZED O & M COST			
(Uniform Series Present Worth for	1 Yrs.)		
3%	0.971 factor		$619,806
5%	0.952 factor		$608,000
10%	0.909 factor		$580,364
October '90 to October '92	Pumping rate 0 gpm		
2 years Duration	Treatment plant on standby		
Monitoring (O & M)		$14,000 /MO.	
Total Plant Operation (O & M)	(on standby)	$4,000 /MO.	
		$18,000 /MO. =	$432,000
NET PRESENT WORTH OF ANNUALIZED O & M COST			
(Uniform Series Present Worth for	2 Yrs.)		
3%	1.913 factor		$826,619
5%	1.859 factor		$803,265
10%	1.736 factor		$749,752
June '89 to October '89	Install five new wells and pipline		
Construction Cost			$275,000
TOTAL PRESENT WORTH OF ANNUALIZED O & M AND CAPITAL COSTS ALTERNATIVE D			
At 3 percent			$1,829,759
At 5 percent			$1,792,260
At 10 percent			$1,707,925

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Table 4-8
COST SUMMARY OF ALTERNATIVE E
PUMP INCREMENTALLY, ADD TWO WELLS - PUMPING RATE : 500gpm to 0
6.67 Years (April '89 to Jan. '96)
FIRESTONE

Cost Items			Annual Estimated Costs
April '89 to July '89 0.25 Years Duration	Pumping rate @ 500gpm Pump & treat on and offsite wells	Onsite Wells	
Construction Costs All capital costs are "sunk" and not a part of this evaluation.			
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. :	$638,400
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 0.25 Yrs.)			
3%	0.245 factor		$156,673
5%	0.242 factor		$154,792
10%	0.235 factor		$150,317
July '89 to November '89 0.33 Years Duration	Pumping rate @ 500 gpm	Offsite wells	
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. :	$638,400
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 0.33 Yrs.)			
3%	0.324 factor		$206,565
5%	0.319 factor		$203,928
10%	0.310 factor		$197,667
November '89 to January '94 4.17 Years Duration	Pumping rate @ 500 gpm Pump and treat	120' depth	
Monitoring (O & M)		$18,000 /MO.	
Total Plant Operation (O & M)		$35,200 /MO.	
		$53,200 /MO. :	$638,400
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 4.17 Yrs.)			
3%	3.866 factor		$2,467,765
5%	3.682 factor		$2,350,500
10%	3.280 factor		$2,093,723

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Table 4-8 (cont.)
COST SUMMARY (CONTINUED) OF ALTERNATIVE E
PUMP INCREMENTALLY, ADD TWO WELLS - PUMPING RATE : 500gpm to 0
6.67 Years (April '89 to Jan. '96)
FIRESTONE

Cost Items			Annual Estimated Costs
January '94 thru January '96	Pumping rate @ 0 gpm	Monitor only, plant on standby.	
2 Years Duration	Pump & treat ends 01/94		
Construction Costs All capital costs are "sunk" and not a part of this evaluation.			
Monitoring (O & M)		$14,000 /MO.	
Total Plant Operation (O & M)	(on standby)	$4,000 /MO.	
		$18,000 /MO. =	$216,000
NET PRESENT WORTH OF ANNUALIZED O & M COST (Uniform Series Present Worth for 2 Yrs.)			
3%	1.913 factor		$413,309
5%	1.859 factor		$401,633
10%	1.736 factor		$374,876
Construction Costs Two new (120') wells and pipeline			$200,000
TOTAL PRESENT WORTH OF ALTERNATIVE E			
At 3 percent			$3,444,312
At 5 percent			$3,310,854
At 10 percent			$3,016,583

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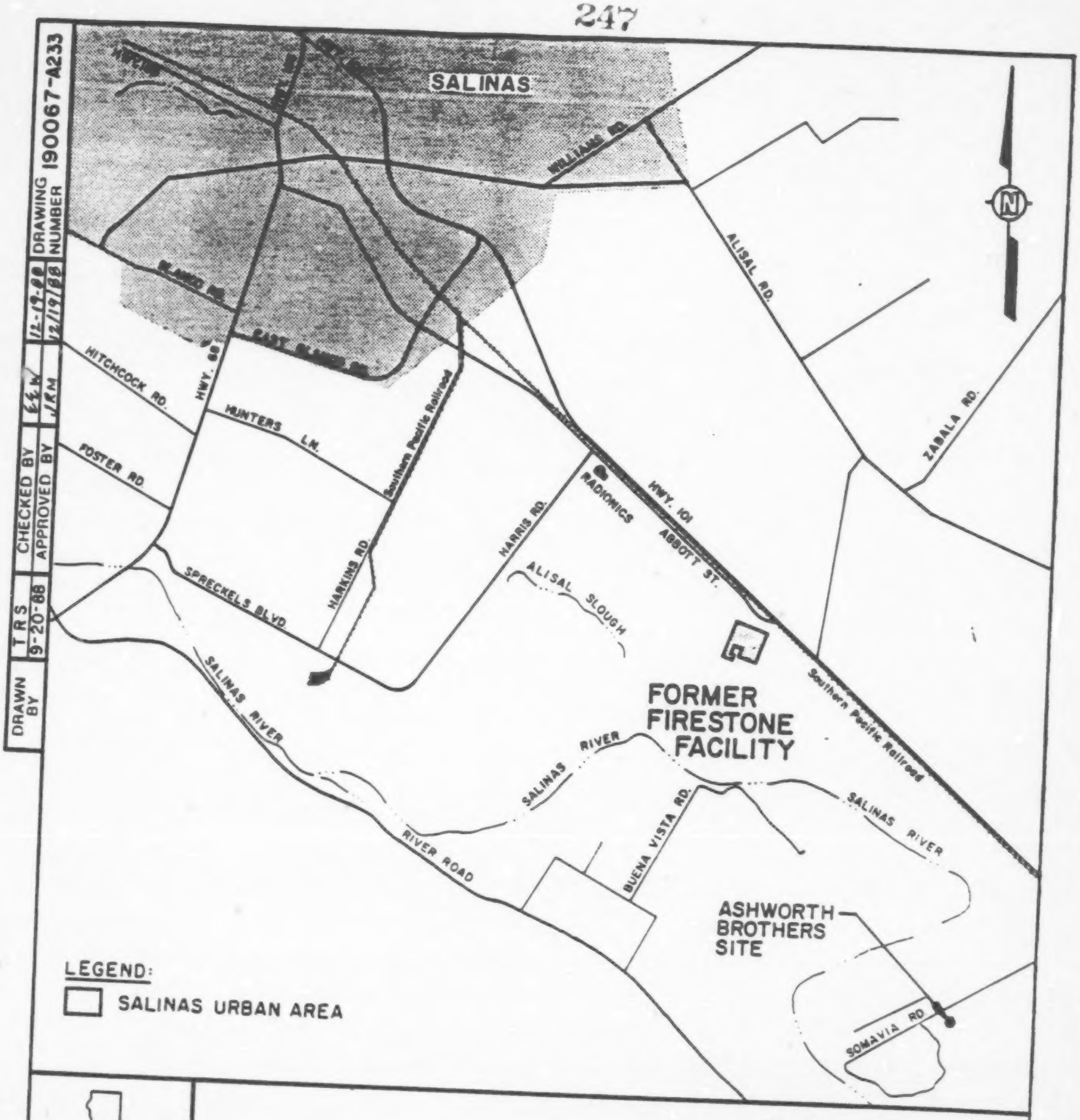
APPROVED BY	JRM 12/19/88
DRAWING NUMBER	190067-A233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HITCHCOCK RD.
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HUNTERS LN.
FOSTER RD
Southern Pacific Railroad
HARRIS RD.
RADIONICS
HWY. 101
ABBOTT ST.
HARKINS RD.
SPRECKELS BLVD
ALISAL SLOUGH
FORMER FIRESTONE FACILITY
Southern Pacific Railroad
SALINAS RIVER
SALINAS RIVER
SALINAS RIVER
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RIVER ROAD
ASHWORTH BROTHERS SITE
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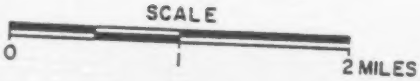
SALINAS URBAN AREA


SCALE
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2 MILES

REFERENCE:
7.5 MIN. U.S.G.S. TOPOGRAPHIC MAP OF CHULAR, NATIVIDAD, SALINAS & SPRECKELS, CALIFORNIA QUADRANGLES, DATED 1947, PHOTOREVISED 1968, 1984, 1975, 1984 RESPECTIVELY. SCALE: 1:24,000

FIGURE 1-1

VICINITY MAP
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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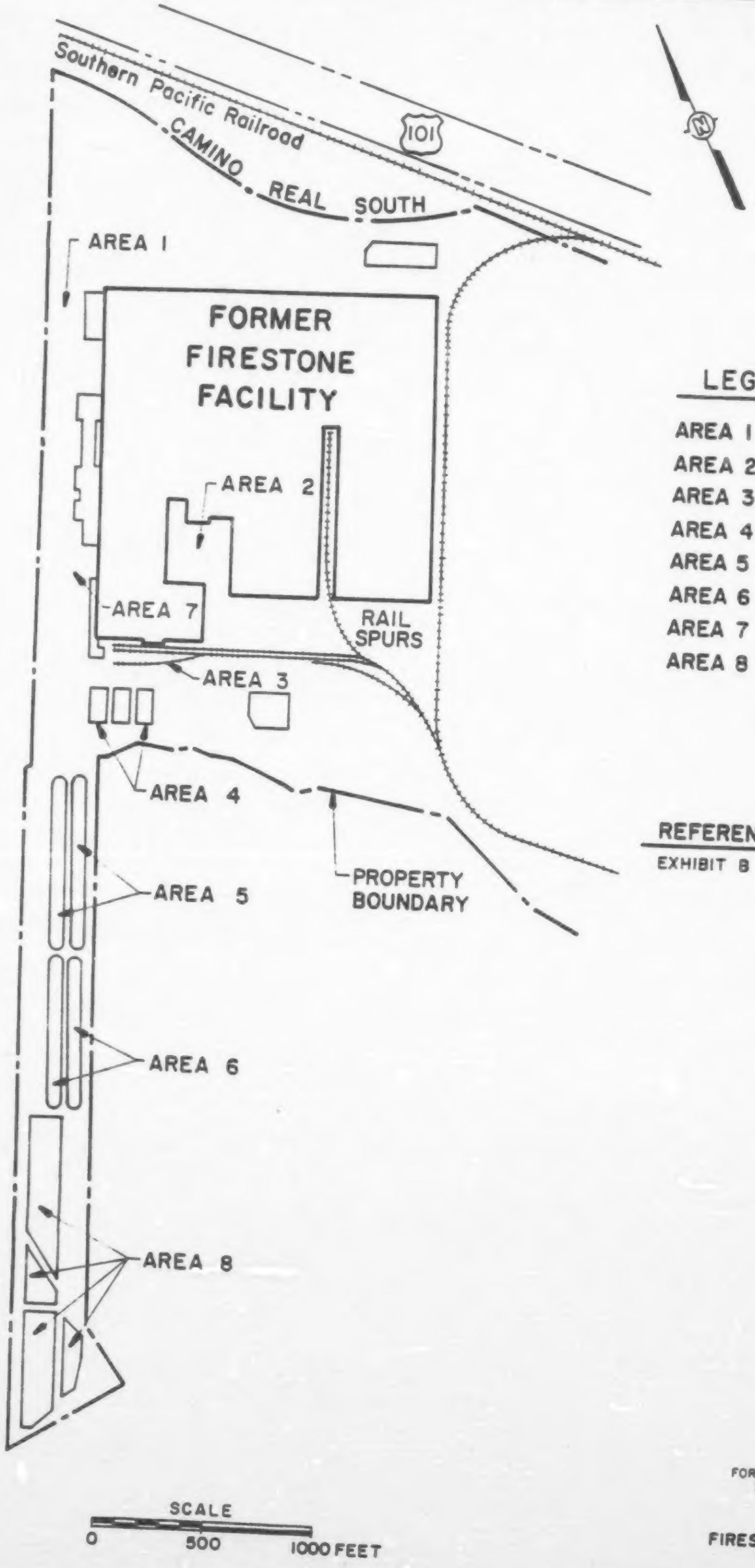

Southern Pacific Railroad
101
CAMINO REAL SOUTH
N
AREA 1
FORMER FIRESTONE FACILITY
AREA 2
AREA 7
RAIL SPURS
AREA 3
AREA 4
PROPERTY BOUNDARY
AREA 5
AREA 6
AREA 8
SCALE
0
500
1000 FEET

LEGEND:

AREA 1	FUEL STORAGE
AREA 2	COURT YARD
AREA 3	RAILCAR UNLOADING
AREA 4	SLUDGE BEDS
AREA 5	HOLDING PONDS
AREA 6	SEEPAGE PONDS
AREA 7	WASTE OIL TANKS
AREA 8	EVAPORATION PONDS

REFERENCE:

EXHIBIT B OF RAO HSA 85/86-002

FIGURE 1-2

SITE PLAN
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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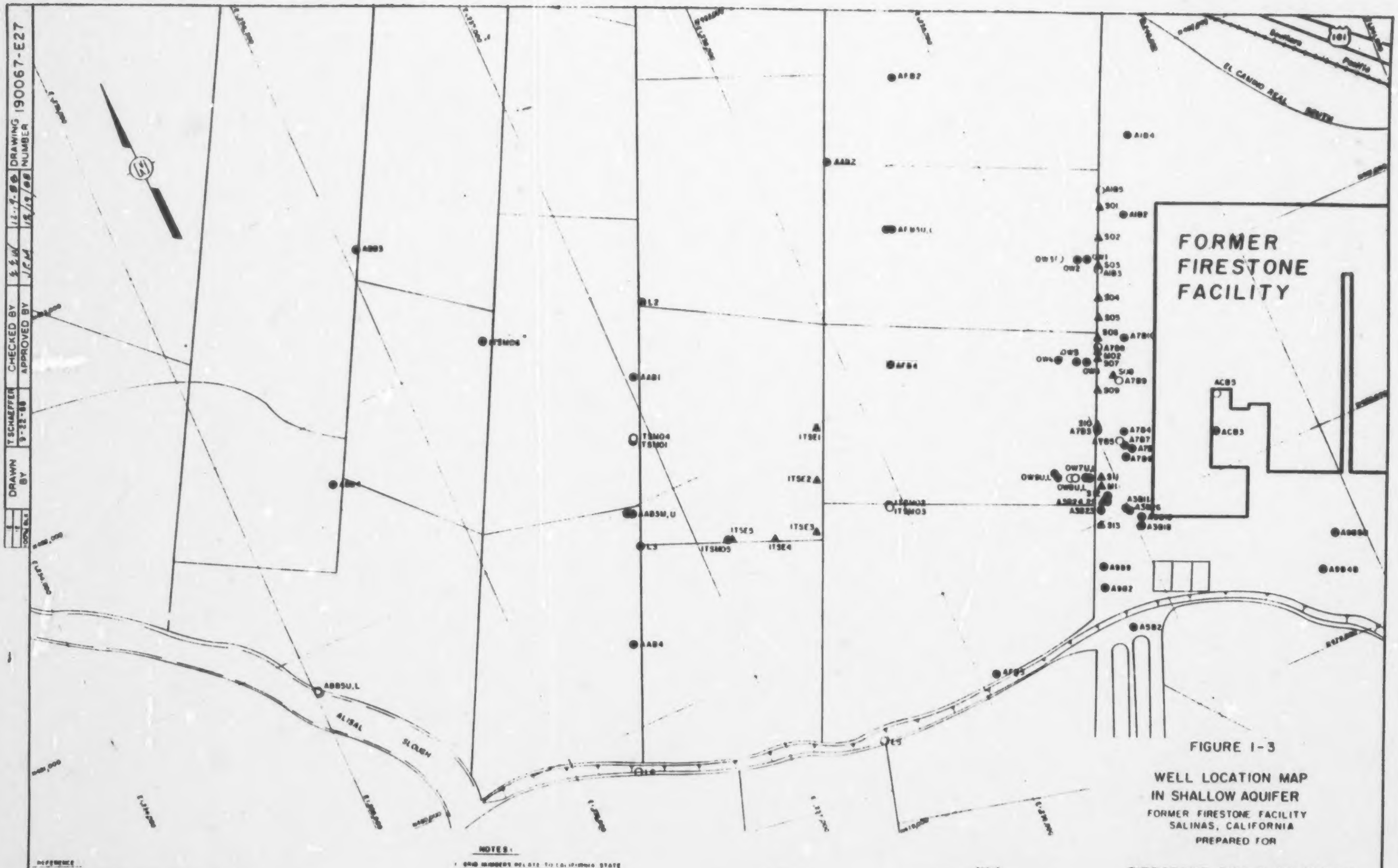
FORMER FIRESTONE FACILITY
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
AFB2
AIB4
AAB2
AIB5
S01
AIB2
S02
AFB5U,L
OW1(?)
OW2
OW1
S03
AIB3
ABB3
S04
S05
L2
S06
A7B10
TSMO6
OW4
OW3
A7B6
MO2
S07
S10
A7B9
AFB4
AAB1
S09
ACB5
TSMO4
TSMO1
ITSE1
ACB3
A7B4
A7B3
A7B7
ABB4
ITSE2
OW7U,L
OW8U,L
S11
OW9U,L
M1
AABSU,U
TSMO3
ITSE5
ITSE3
ITSE4
ITSMO5
L3
S13
A5B10
A9B9
A5B4B
A9B2
AAB4
A5B2
AFB5
ABB5U,L
L5
L4

REFERENCE

MAP BASE COMPILED FROM THE FOLLOWING SOURCES:
FIGURE 1, WELL INVENTORY REPORT, WOODWARD CLYDE CONSULTANTS APRIL 1980,
"WELL FIELD MAP", WOODWARD CLYDE CONSULTANTS, JUNE 1980,
AND U.S.G.S. CHUALAR AND NATIVIDAD 7.5 MIN QUADRANGLE SHEETS

NOTES:

1. GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM

LEGEND

● MONITORING WELLS
○ ABANDONED WELLS [illegible]
▲ EXTRACTION WELLS

SCALE
0 200 400 800 FEET

FIGURE 1-3

WELL LOCATION MAP
IN SHALLOW AQUIFER
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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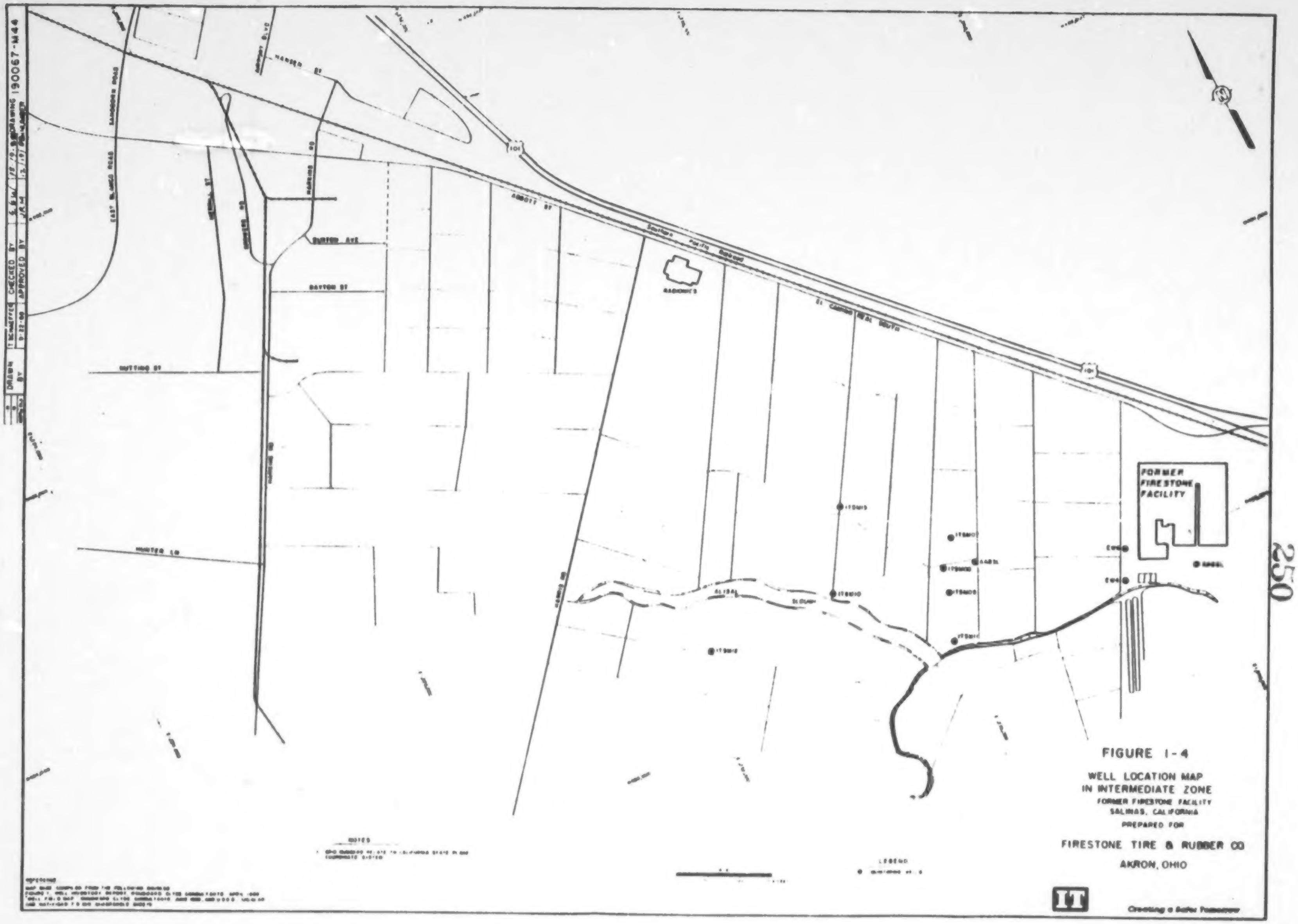
FORMER FIRESTONE FACILITY
101
ABBOTT ST
DAYTON ST
HUNTER LN
EAST BLANCO ROAD
SANBORN ROAD
EL CAMINO REAL SOUTH
SLOUGH
DRAWN BY
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APPROVED BY
DRAWING 190067-M44
LEGEND
NOTES

FIGURE I-4

WELL LOCATION MAP
IN INTERMEDIATE ZONE
FORMER FIRESTONE FACILITY
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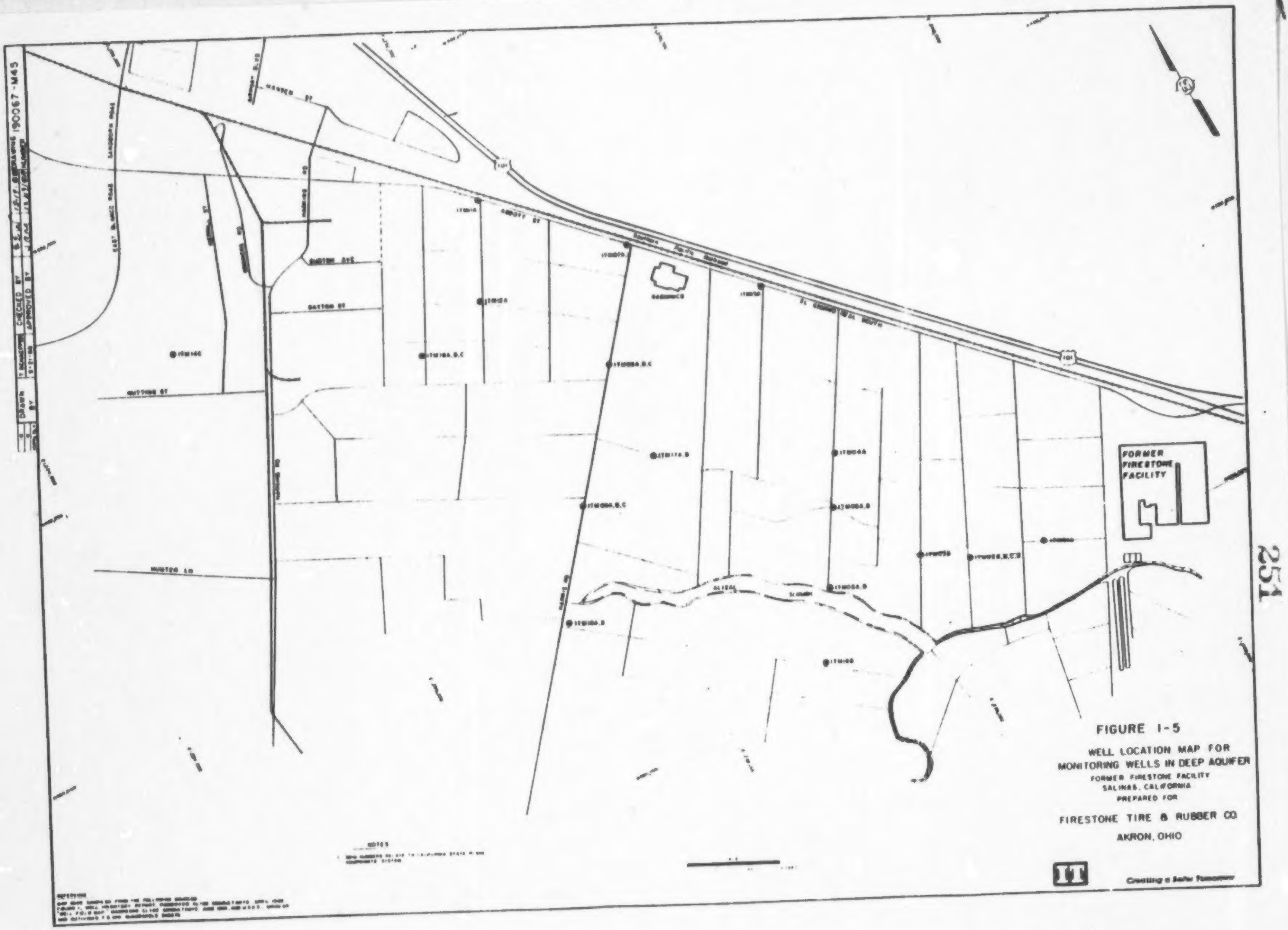
FORMER FIRESTONE FACILITY
101
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NOTES

FIGURE 1-5

WELL LOCATION MAP FOR
MONITORING WELLS IN DEEP AQUIFER
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

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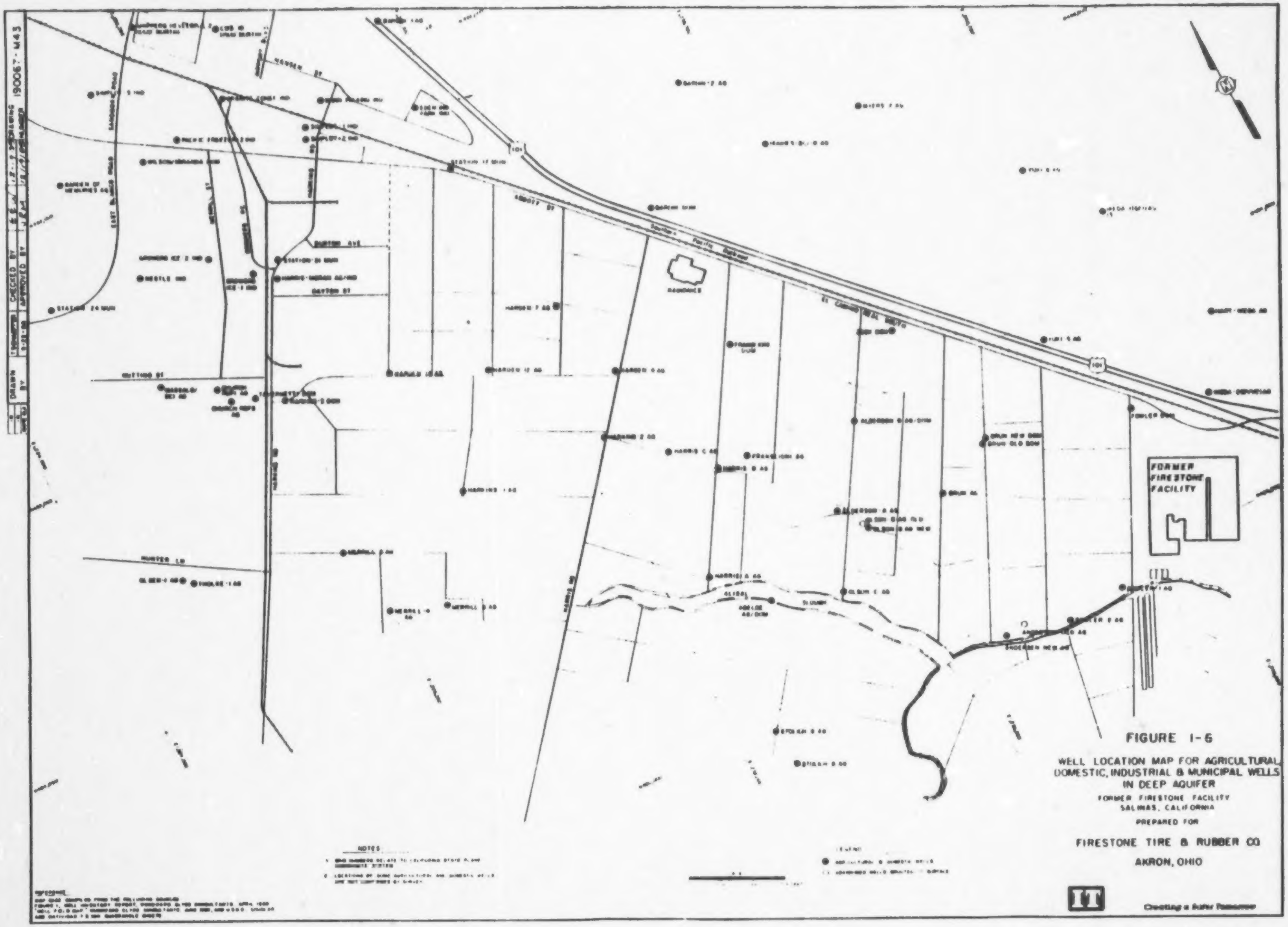
190067-M45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CHECKED BY
APPROVED BY
DRAWING
190067-M43
FORMER FIRESTONE FACILITY
101
NOTES
LEGEND

FIGURE 1-6

WELL LOCATION MAP FOR AGRICULTURAL DOMESTIC, INDUSTRIAL & MUNICIPAL WELLS IN DEEP AQUIFER

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

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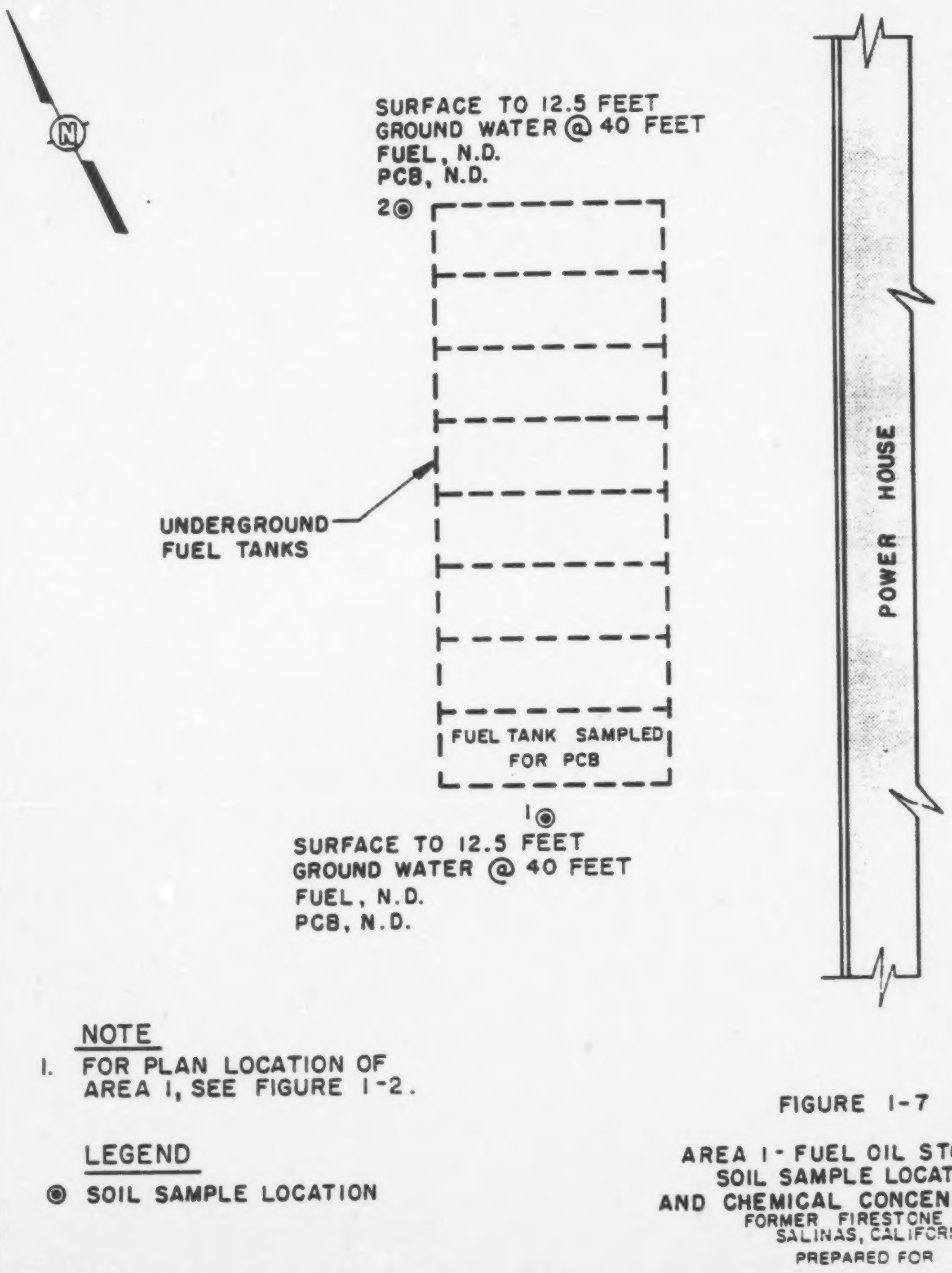
N
SURFACE TO 12.5 FEET
GROUND WATER @ 40 FEET
FUEL, N.D.
PCB, N.D.
2
UNDERGROUND FUEL TANKS
FUEL TANK SAMPLED FOR PCB
1
SURFACE TO 12.5 FEET
GROUND WATER @ 40 FEET
FUEL, N.D.
PCB, N.D.
POWER HOUSE

NOTE

1. FOR PLAN LOCATION OF AREA 1, SEE FIGURE 1-2.

LEGEND

◉ SOIL SAMPLE LOCATION

REFERENCE
WOODWARD-CLYDE CONSULTANTS, 1984a

SCALE
0 20 40 FEET

FIGURE 1-7

AREA 1 - FUEL OIL STORAGE AREA
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
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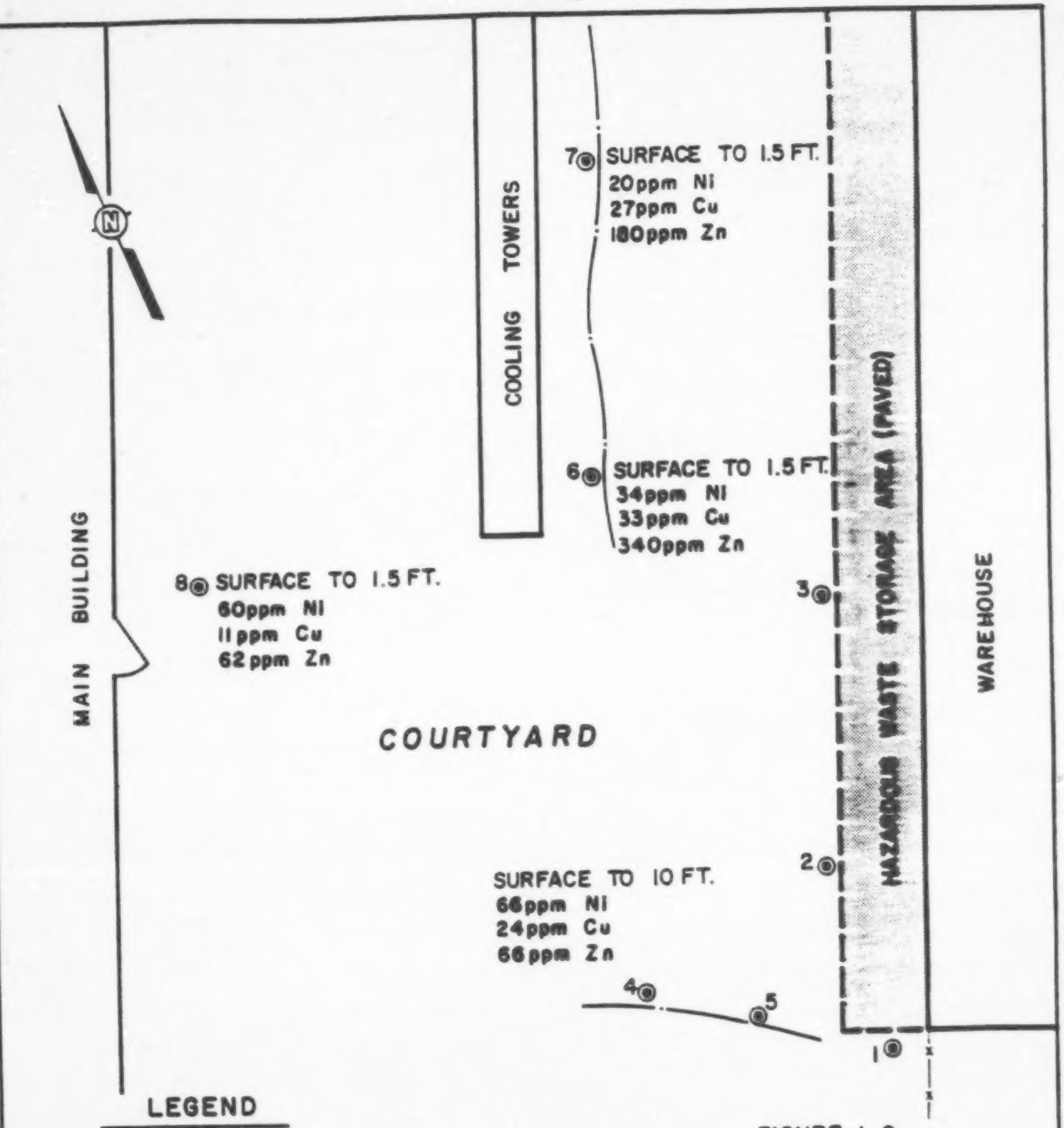
MAIN BUILDING
N
COOLING TOWERS
7 SURFACE TO 1.5 FT.
20ppm Ni
27ppm Cu
180ppm Zn
6 SURFACE TO 1.5 FT.
34ppm Ni
33ppm Cu
340ppm Zn
8 SURFACE TO 1.5 FT.
60ppm Ni
11ppm Cu
62 ppm Zn
COURTYARD
3
2
SURFACE TO 10 FT.
66ppm Ni
24ppm Cu
66ppm Zn
4
5
1
HAZARDOUS WASTE STORAGE AREA (PAVED)
WAREHOUSE

LEGEND

◉ SOIL SAMPLE LOCATION

—·— DRAINAGE DITCH

NOTES

1. FOR PLAN LOCATION OF AREA 2, SEE FIGURE 1-2

FIGURE 1-8

AREA 2-HAZARDOUS WASTE STORAGE AREA
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED BY
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

REFERENCE

WOODWARD-CLYDE
CONSULTANTS, 1984a

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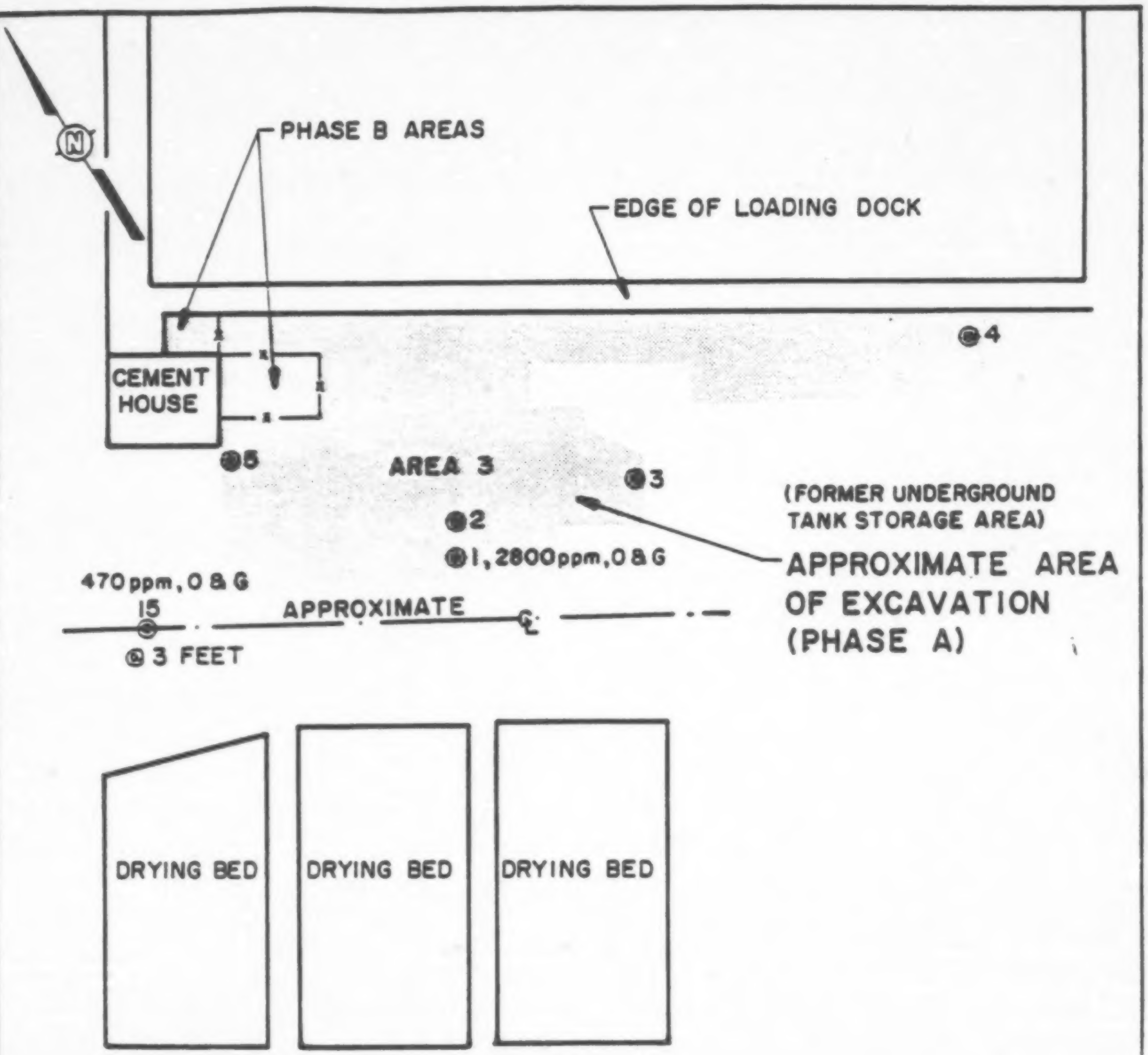
N
PHASE B AREAS
EDGE OF LOADING DOCK
CEMENT HOUSE
4
5
AREA 3
3
2
1, 2800ppm, O & G
(FORMER UNDERGROUND TANK STORAGE AREA)
APPROXIMATE AREA OF EXCAVATION (PHASE A)
470 ppm, O & G
15
@ 3 FEET
APPROXIMATE ℄
DRYING BED
DRYING BED
DRYING BED

NOTES

1. ALL SAMPLES TAKEN AT BOTTOM OF EXCAVATION
2. FOR PLAN LOCATION OF AREA 3 SEE FIGURE 1-2

LEGEND

● SOIL SAMPLE LOCATION

-·- DRAINAGE DITCH

FIGURE 1-9

AREA 3 - RAW MATERIALS STORAGE AREA
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

REFERENCE
WOODWARD - CLYDE CONSULTANTS, 1984a

SCALE
0 50 100 FEET

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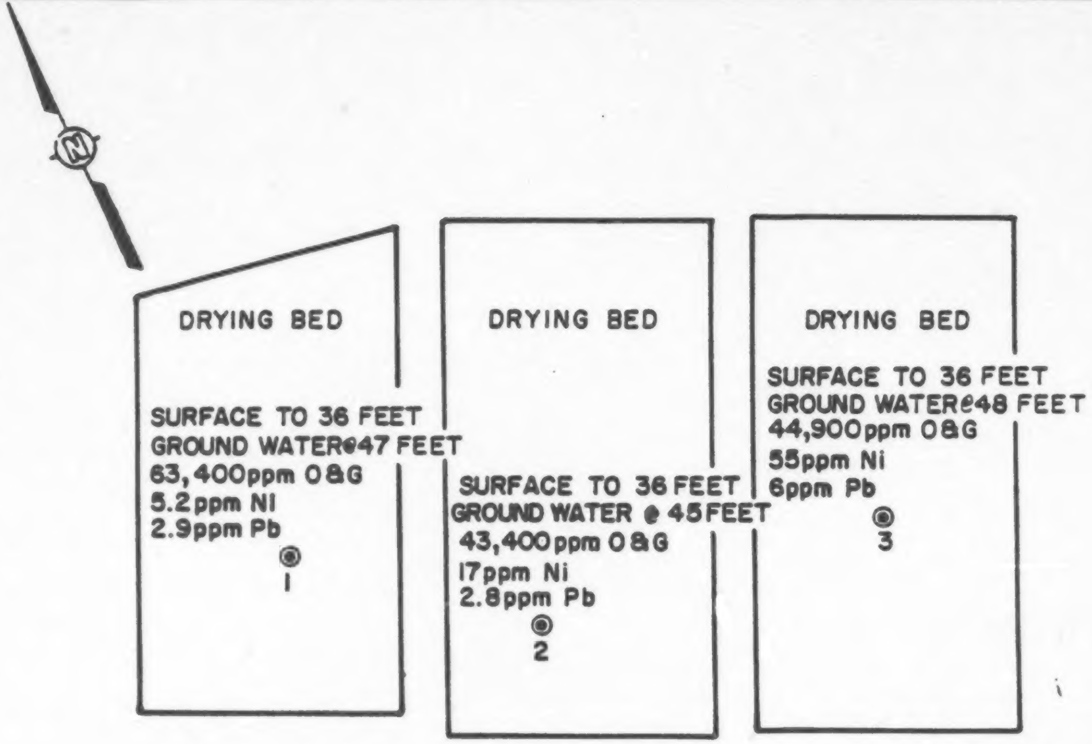
N
DRYING BED
SURFACE TO 36 FEET
GROUND WATER@47 FEET
63,400ppm O&G
5.2ppm Ni
2.9ppm Pb
1
DRYING BED
SURFACE TO 36 FEET
GROUND WATER @ 45 FEET
43,400ppm O&G
17ppm Ni
2.8ppm Pb
2
DRYING BED
SURFACE TO 36 FEET
GROUND WATER@48 FEET
44,900ppm O&G
55ppm Ni
6ppm Pb
3

NOTES

1. FOR PLAN LOCATION OF AREA 4, SEE FIGURE 1-2

LEGEND

● SOIL SAMPLE LOCATION

O&G OIL AND GREASE

FIGURE 1-10

AREA 4-THREE SLUDGE DRYING BEDS
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

REFERENCE:
WOODWARD-CLYDE CONSULTANTS, 1984a

SCALE
0 50 100 FEET

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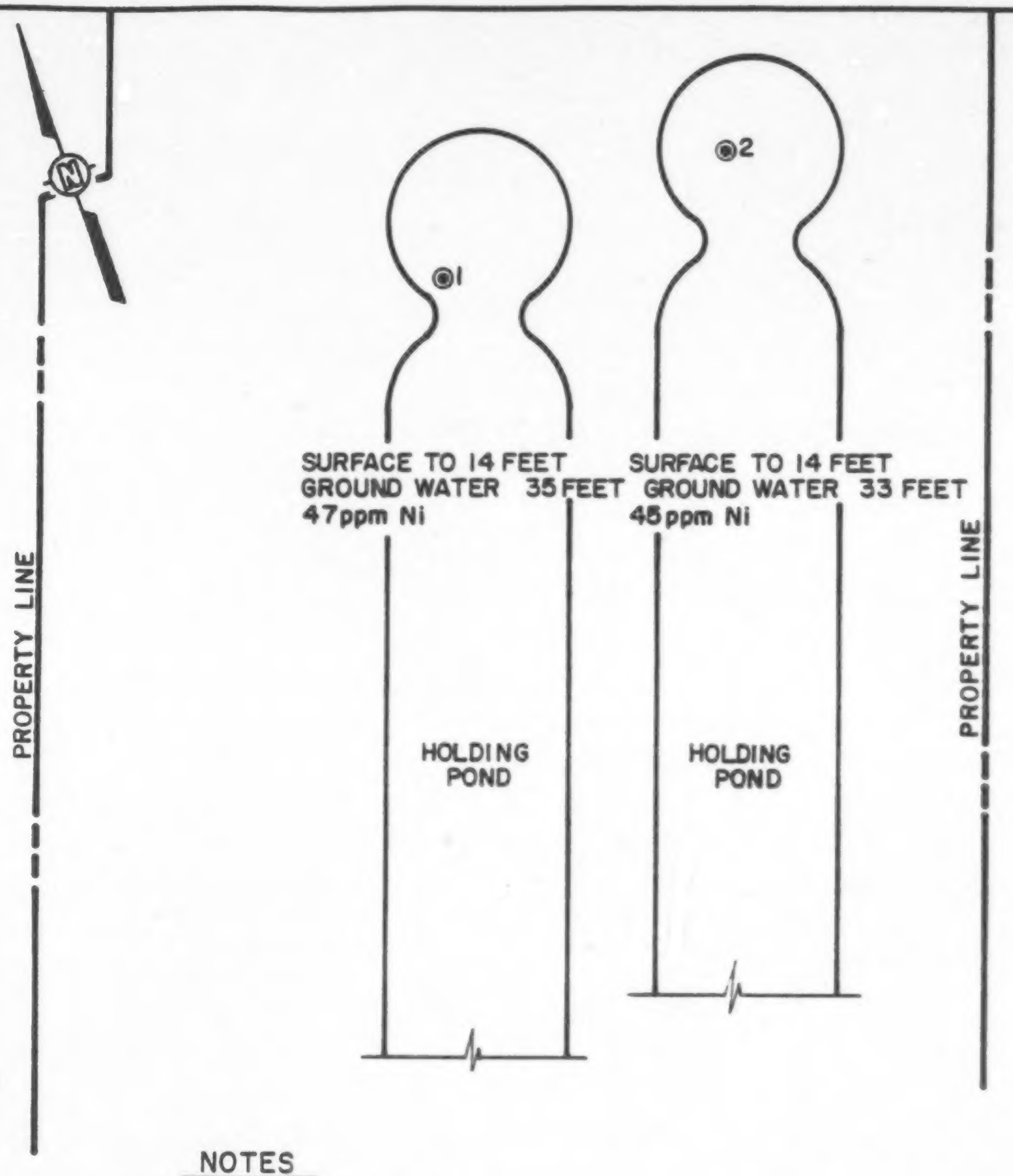
N
PROPERTY LINE
⦿1
⦿2
SURFACE TO 14 FEET
GROUND WATER 35 FEET
47ppm Ni
SURFACE TO 14 FEET
GROUND WATER 33 FEET
45ppm Ni
HOLDING POND
HOLDING POND
PROPERTY LINE

NOTES

1. FOR PLAN LOCATION OF AREA 5, SEE FIGURE 1-2

LEGEND

⦿ SOIL SAMPLE LOCATION

FIGURE 1-11

AREA 5 - HOLDING PONDS SOIL SAMPLE LOCATIONS AND CHEMICAL CONCENTRATIONS

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

REFERENCE

WOODWARD-CLYDE CONSULTANTS, 1984a

SCALE

0 50 100 FEET

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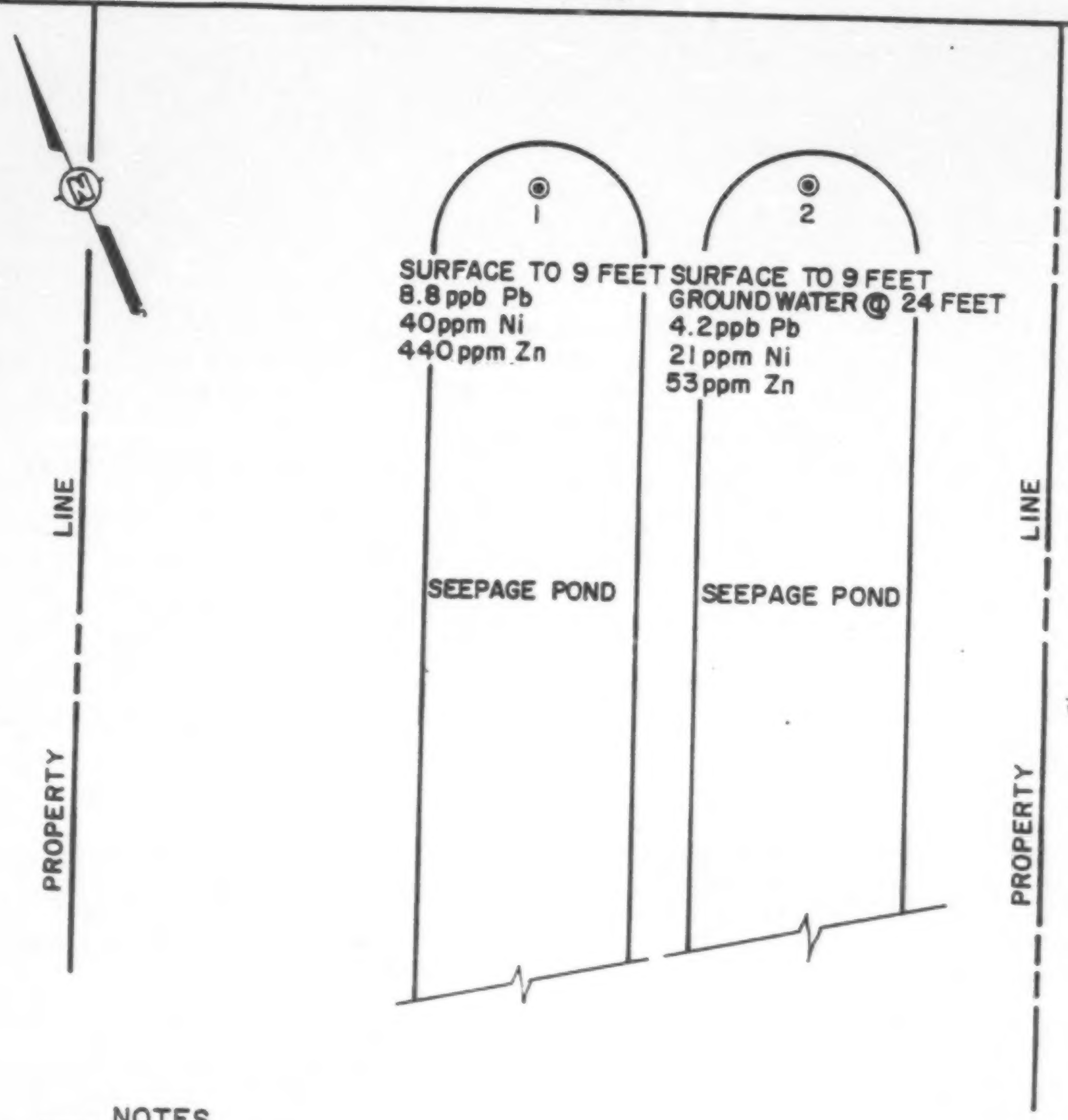
N
PROPERTY LINE
1
SURFACE TO 9 FEET
8.8 ppb Pb
40 ppm Ni
440 ppm Zn
2
SURFACE TO 9 FEET
GROUND WATER @ 24 FEET
4.2 ppb Pb
21 ppm Ni
53 ppm Zn
SEEPAGE POND
SEEPAGE POND
PROPERTY LINE

NOTES

1. FOR PLAN LOCATION OF AREA 6, SEE FIGURE 1-2

FIGURE 1-12

LEGEND

◉ SOIL SAMPLE LOCATION

AREA 6 - SEEPAGE PONDS
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
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AKRON, OHIO

REFERENCE:
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SCALE
0 50 100 FEET

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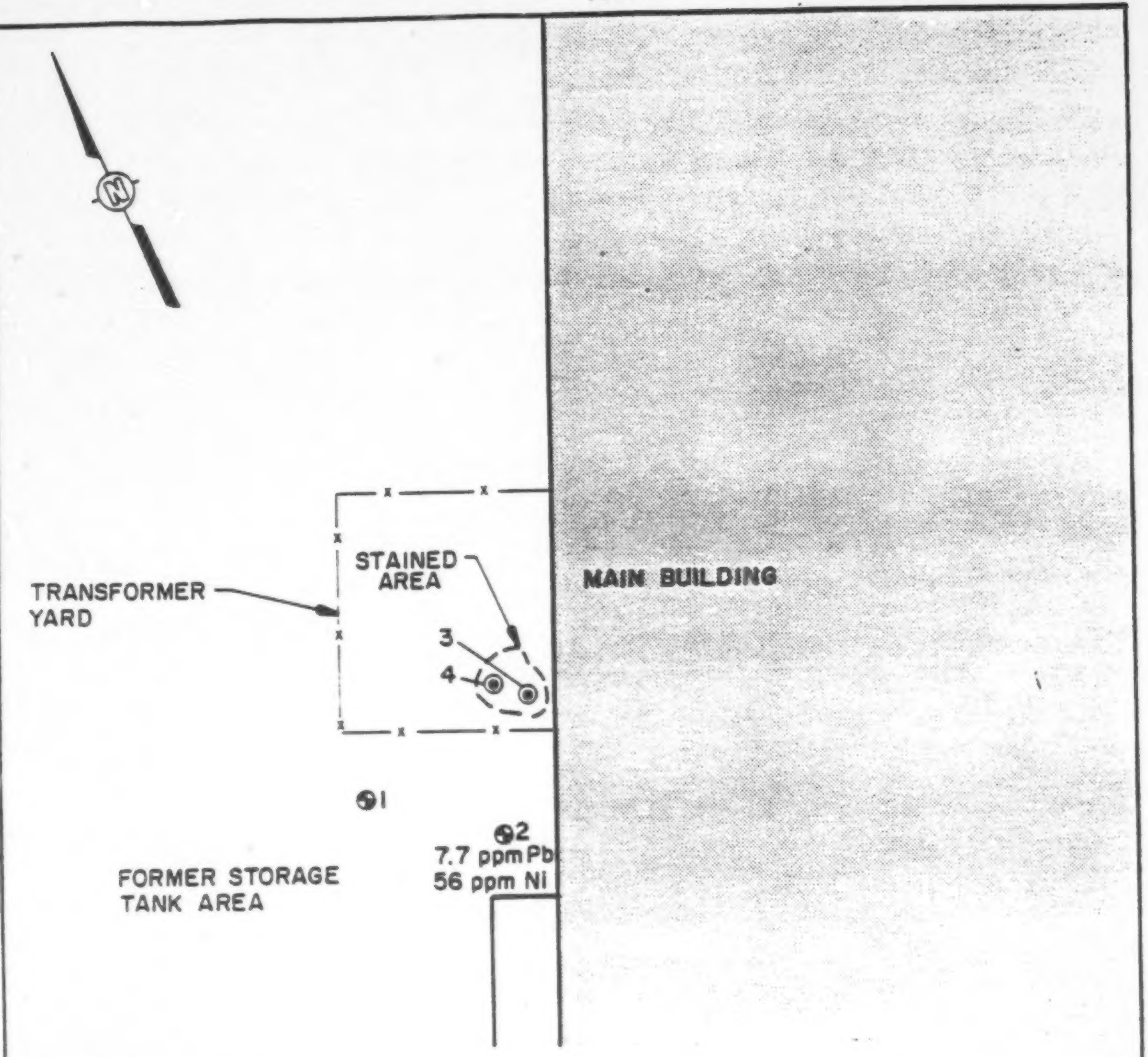
N
TRANSFORMER YARD
STAINED AREA
MAIN BUILDING
3
4
1
2
7.7 ppm Pb
56 ppm Ni
FORMER STORAGE TANK AREA

NOTES

1. FOR PLAN LOCATION OF AREA 7, SEE FIGURE 1-2

LEGEND

- ⊕ WELL LOCATION
- ◉ SOIL SAMPLE LOCATION

REFERENCE
WOODWARD-CLYDE CONSULTANTS, 1984a

SCALE
0 50 100FEET

FIGURE 1-13

AREA 7 - TRANSFORMER YARD AND WASTE OIL TANKS SOIL SAMPLE LOCATIONS AND CHEMICAL CONCENTRATIONS
FORMER FIRESTONE FACILITY
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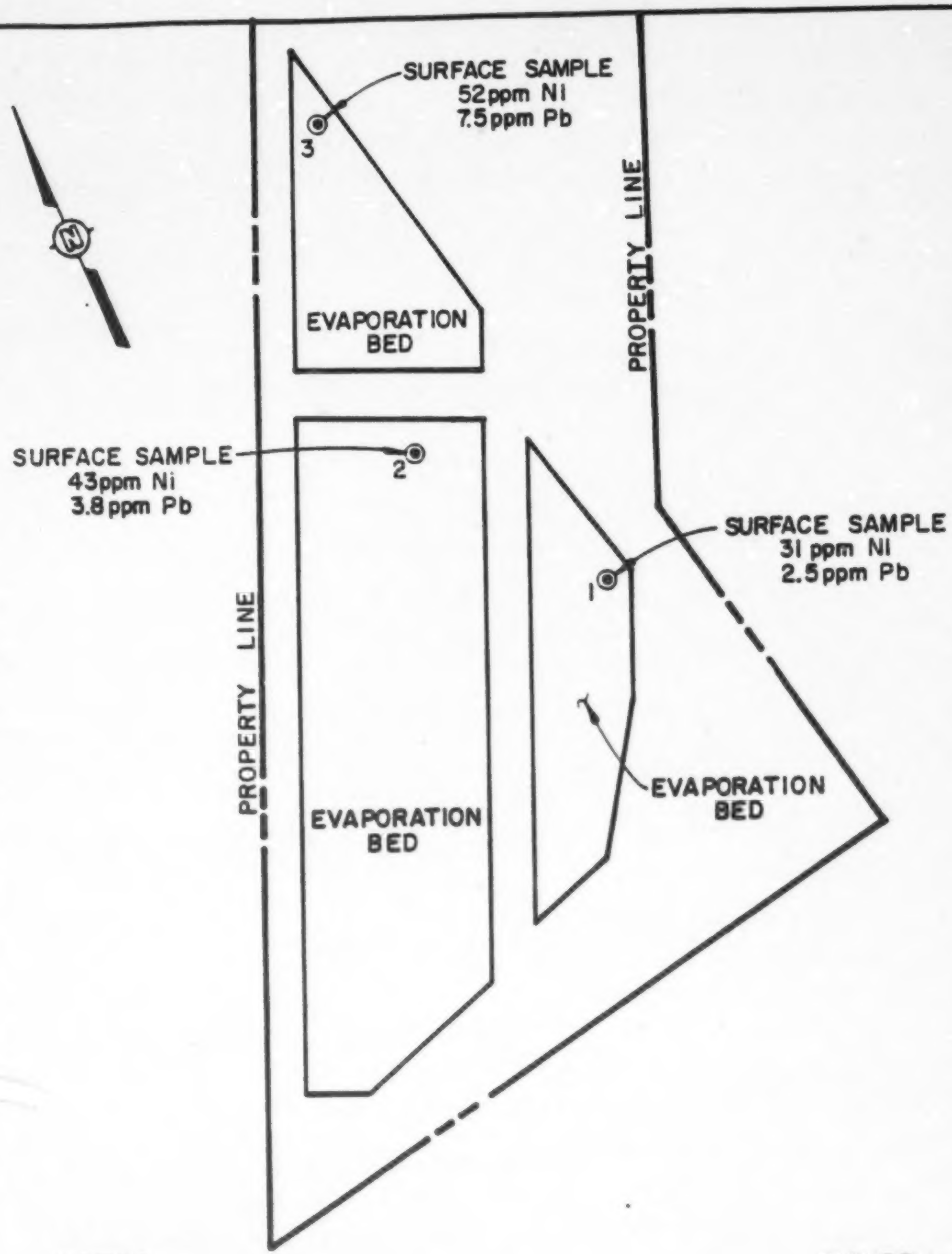
SURFACE SAMPLE
52ppm Ni
7.5ppm Pb
3
EVAPORATION BED
PROPERTY LINE
SURFACE SAMPLE
43ppm Ni
3.8ppm Pb
2
SURFACE SAMPLE
31 ppm Ni
2.5ppm Pb
1
PROPERTY LINE
EVAPORATION BED
EVAPORATION BED
N

NOTES

1. FOR PLAN LOCATION OF AREA 8, SEE FIGURE 1-2

LEGEND

◉ SOIL SAMPLE LOCATION

REFERENCE

WOODWARD - CLYDE CONSULTANTS, 1984a

SCALE

0 50 100 FEET

FIGURE 1-14

AREA 8 - EVAPORATION BEDS
SOIL SAMPLE LOCATIONS
AND CHEMICAL CONCENTRATIONS
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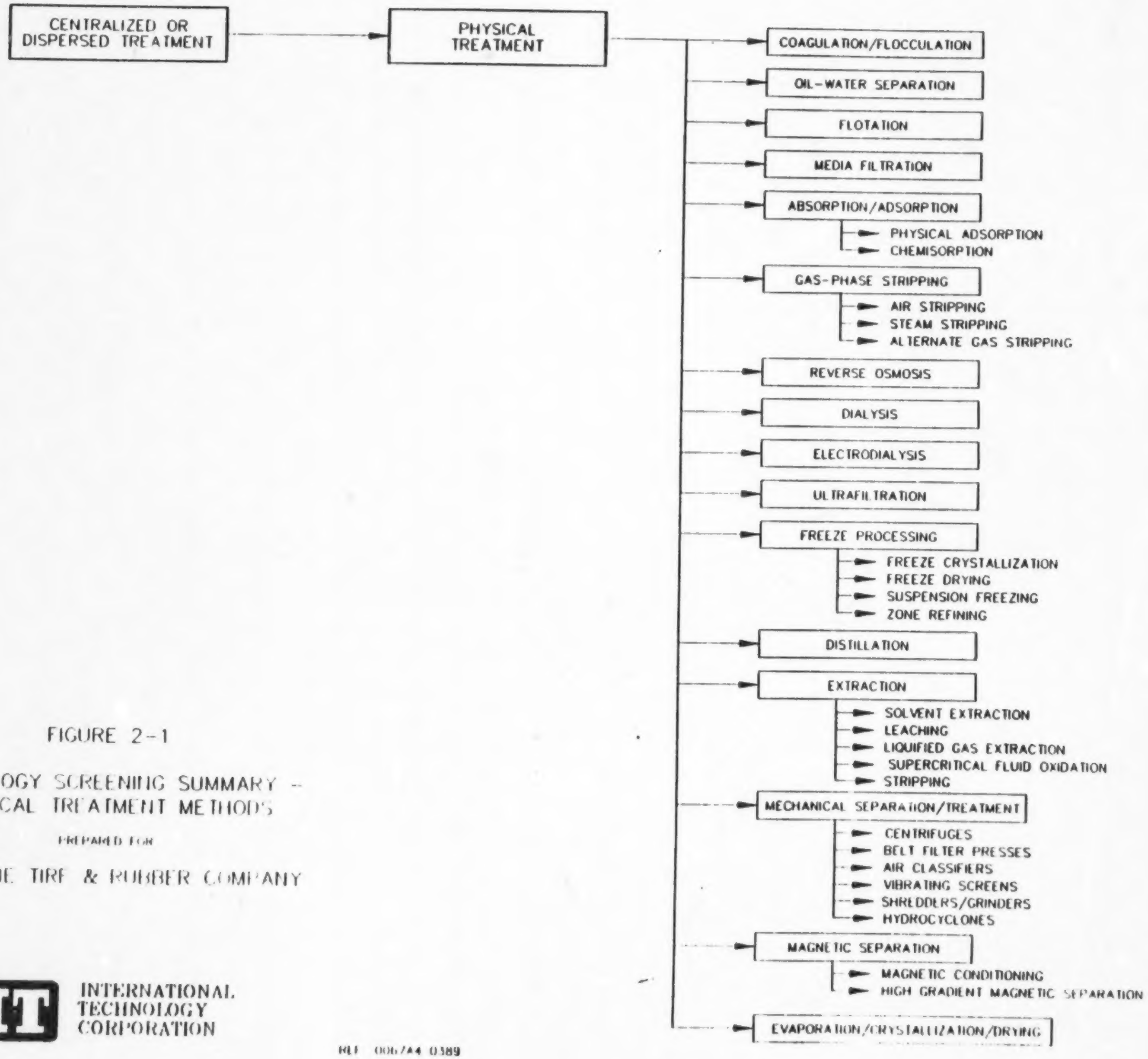
CENTRALIZED OR DISPERSED TREATMENT
PHYSICAL TREATMENT
COAGULATION/FLOCCULATION
OIL-WATER SEPARATION
FLOTATION
MEDIA FILTRATION
ABSORPTION/ADSORPTION
PHYSICAL ADSORPTION
CHEMISORPTION
GAS-PHASE STRIPPING
AIR STRIPPING
STEAM STRIPPING
ALTERNATE GAS STRIPPING
REVERSE OSMOSIS
DIALYSIS
ELECTRODIALYSIS
ULTRAFILTRATION
FREEZE PROCESSING
FREEZE CRYSTALLIZATION
FREEZE DRYING
SUSPENSION FREEZING
ZONE REFINING
DISTILLATION
EXTRACTION
SOLVENT EXTRACTION
LEACHING
LIQUIFIED GAS EXTRACTION
SUPERCRITICAL FLUID OXIDATION
STRIPPING
MECHANICAL SEPARATION/TREATMENT
CENTRIFUGES
BELT FILTER PRESSES
AIR CLASSIFIERS
VIBRATING SCREENS
SHREDDERS/GRINDERS
HYDROCYCLONES
MAGNETIC SEPARATION
MAGNETIC CONDITIONING
HIGH GRADIENT MAGNETIC SEPARATION
EVAPORATION/CRYSTALLIZATION/DRYING

FIGURE 2-1

TECHNOLOGY SCREENING SUMMARY - PHYSICAL TREATMENT METHODS

PREPARED FOR

FIRESTONE TIRE & RUBBER COMPANY

INTERNATIONAL
TECHNOLOGY
CORPORATION

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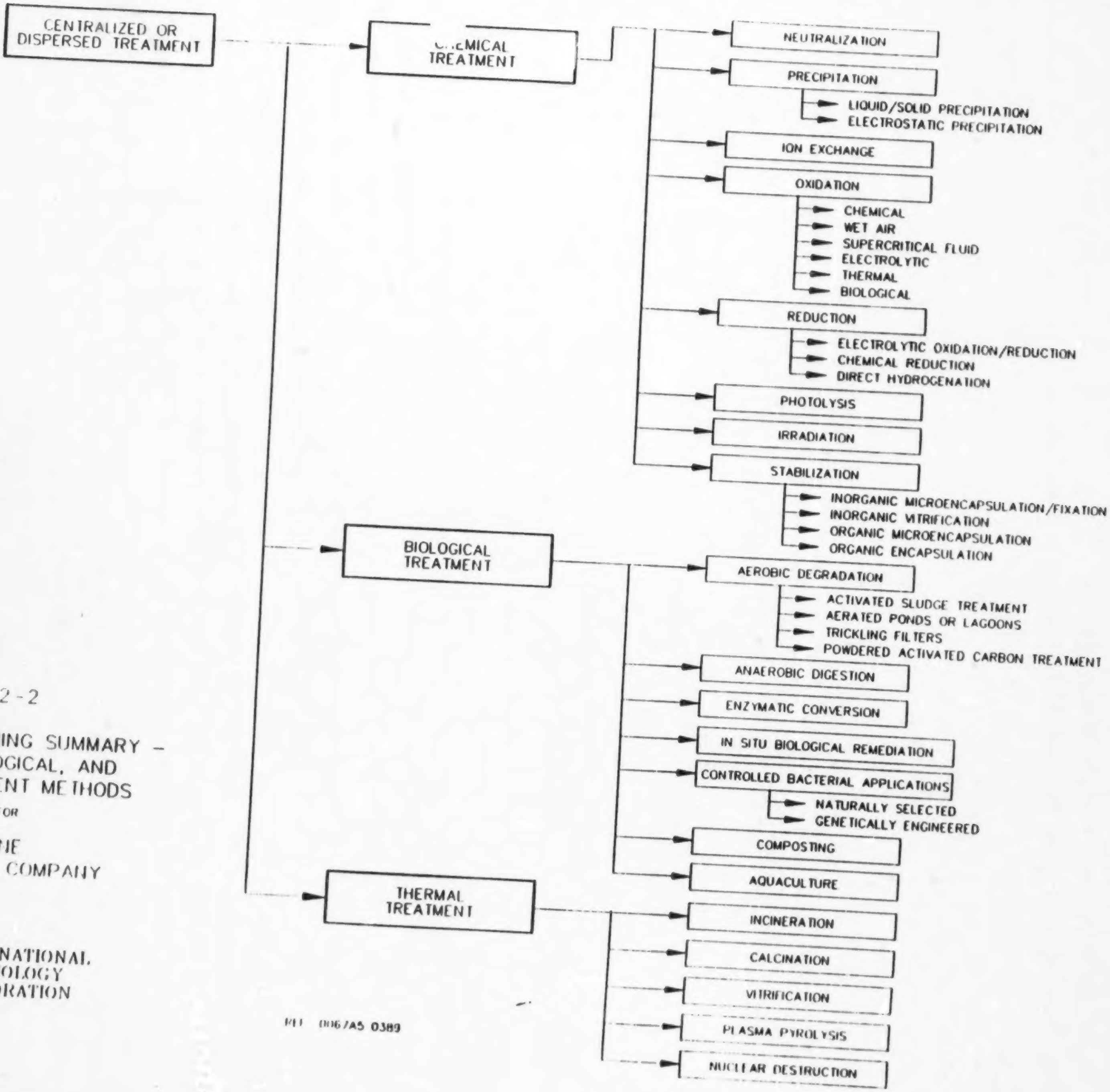
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CHEMICAL TREATMENT
NEUTRALIZATION
PRECIPITATION
LIQUID/SOLID PRECIPITATION
ELECTROSTATIC PRECIPITATION
ION EXCHANGE
OXIDATION
CHEMICAL
WET AIR
SUPERCRITICAL FLUID
ELECTROLYTIC
THERMAL
BIOLOGICAL
REDUCTION
ELECTROLYTIC OXIDATION/REDUCTION
CHEMICAL REDUCTION
DIRECT HYDROGENATION
PHOTOLYSIS
IRRADIATION
STABILIZATION
INORGANIC MICROENCAPSULATION/FIXATION
INORGANIC VITRIFICATION
ORGANIC MICROENCAPSULATION
ORGANIC ENCAPSULATION
BIOLOGICAL TREATMENT
AEROBIC DEGRADATION
ACTIVATED SLUDGE TREATMENT
AERATED PONDS OR LAGOONS
TRICKLING FILTERS
POWDERED ACTIVATED CARBON TREATMENT
ANAEROBIC DIGESTION
ENZYMATIC CONVERSION
IN SITU BIOLOGICAL REMEDIATION
CONTROLLED BACTERIAL APPLICATIONS
NATURALLY SELECTED
GENETICALLY ENGINEERED
COMPOSTING
AQUACULTURE
THERMAL TREATMENT
INCINERATION
CALCINATION
VITRIFICATION
PLASMA PYROLYSIS
NUCLEAR DESTRUCTION

FIGURE 2-2

TECHNOLOGY SCREENING SUMMARY –
CHEMICAL, BIOLOGICAL, AND
THERMAL TREATMENT METHODS

PREPARED FOR

FIRESTONE
TIRE & RUBBER COMPANY

INTERNATIONAL
TECHNOLOGY
CORPORATION

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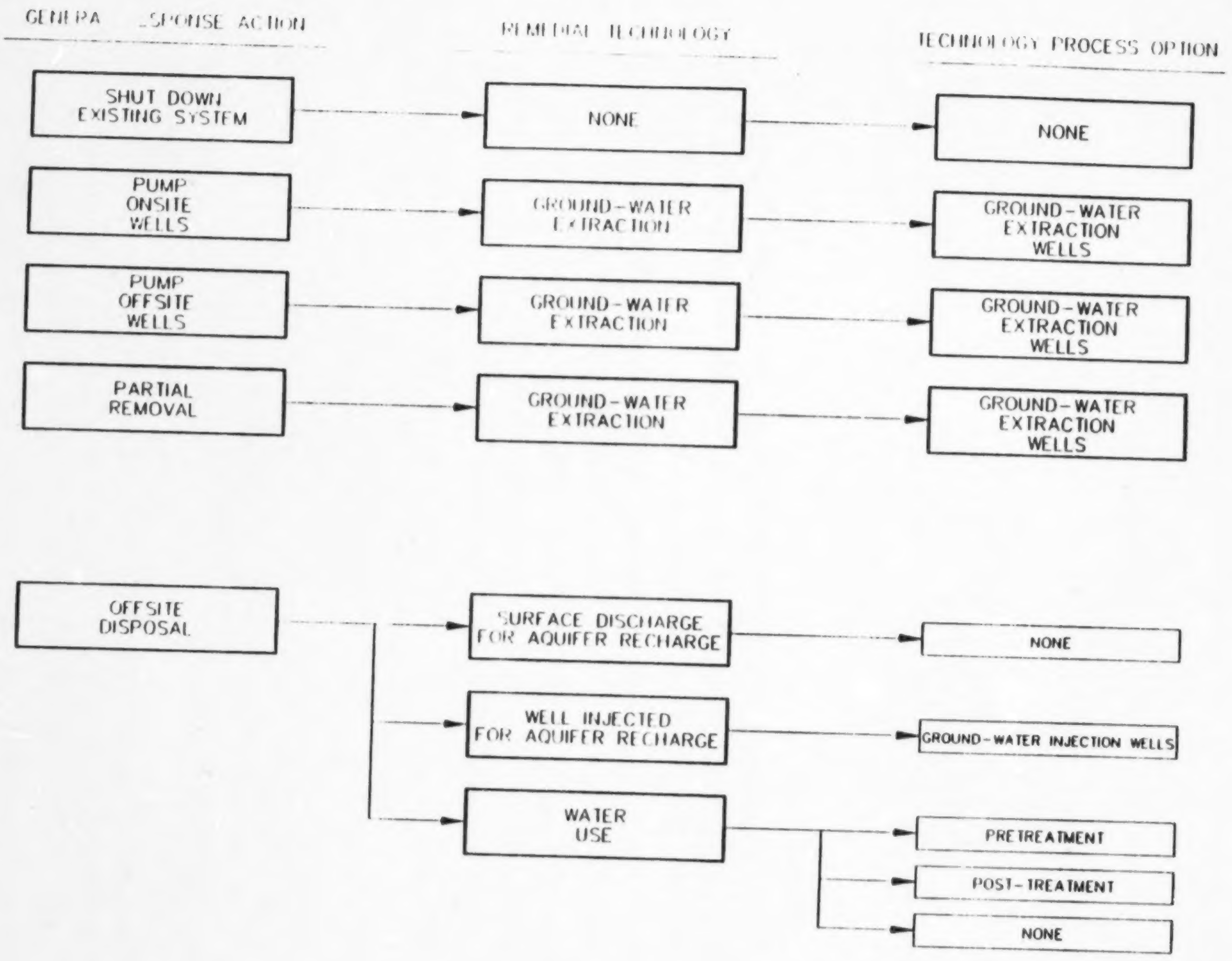
GENERAL RESPONSE ACTION
REMEDIAL TECHNOLOGY
TECHNOLOGY PROCESS OPTION
SHUT DOWN EXISTING SYSTEM
NONE
NONE
PUMP ONSITE WELLS
GROUND-WATER EXTRACTION
GROUND-WATER EXTRACTION WELLS
PUMP OFFSITE WELLS
GROUND-WATER EXTRACTION
GROUND-WATER EXTRACTION WELLS
PARTIAL REMOVAL
GROUND-WATER EXTRACTION
GROUND-WATER EXTRACTION WELLS
OFFSITE DISPOSAL
SURFACE DISCHARGE FOR AQUIFER RECHARGE
NONE
WELL INJECTED FOR AQUIFER RECHARGE
GROUND-WATER INJECTION WELLS
WATER USE
PRETREATMENT
POST-TREATMENT
NONE

FIGURE 2-3

TECHNOLOGY SCREENING SUMMARY
TECHNOLOGY PROCESS OPTIONS
PREPARED FOR

FIRESTONE
TIRE & RUBBER
COMPANY

INTERNATIONAL
TECHNOLOGY
CORPORATION

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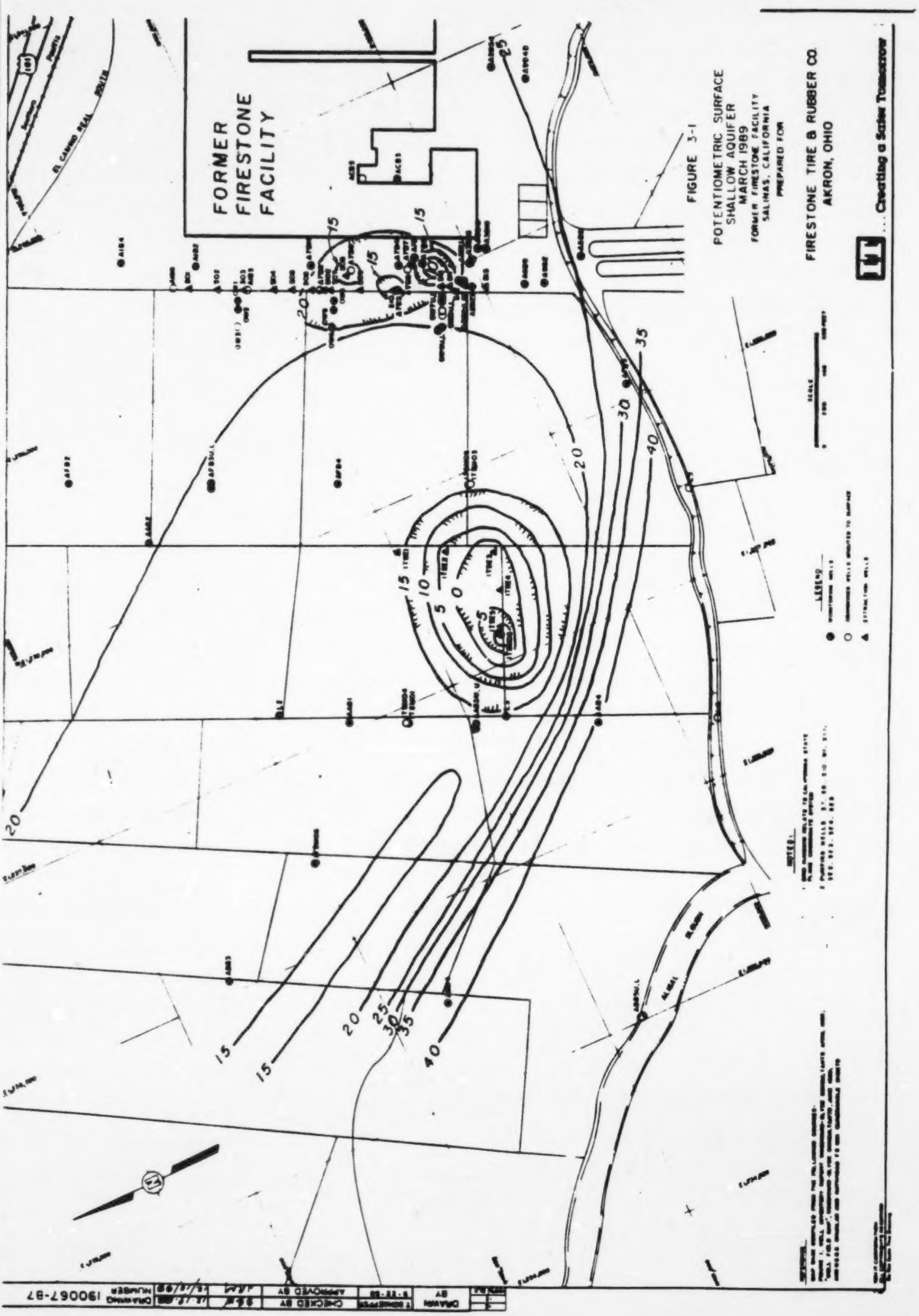
FORMER FIRESTONE FACILITY
EL CAMINO REAL
101
15
10
5
0
20
25
30
35
40
LEGEND
SCALE
DRAWING NUMBER 190067-87
DRAWN BY
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FIGURE 3-1

POTENTIOMETRIC SURFACE
SHALLOW AQUIFER
MARCH 1989
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

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AKRON, OHIO

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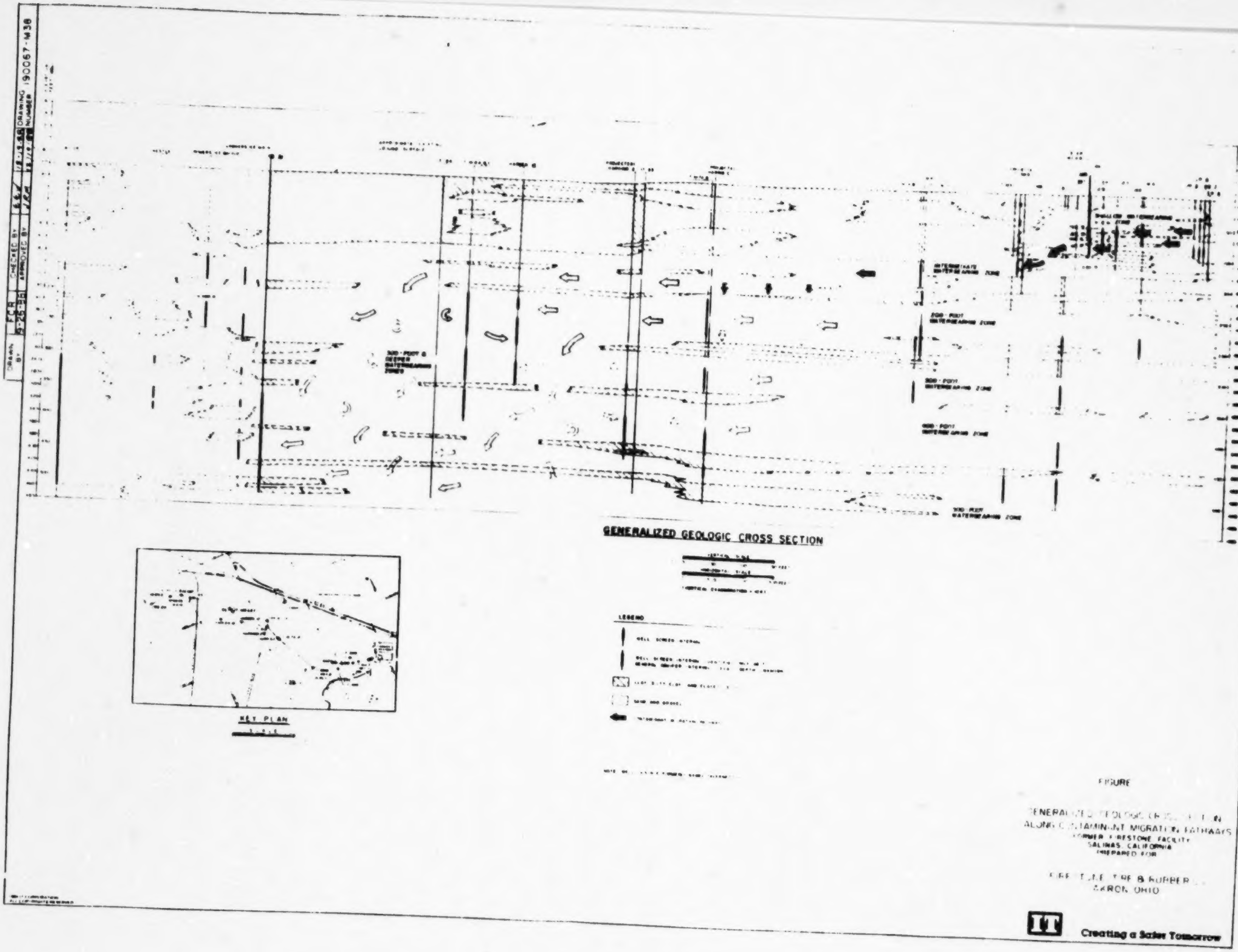
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DRAWING NUMBER 190067-M38
GENERALIZED GEOLOGIC CROSS SECTION
KEY PLAN
LEGEND
INTERMEDIATE WATERBEARING ZONE
SHALLOW WATERBEARING ZONE
FIGURE
GENERALIZED GEOLOGIC CROSS SECTION
ALONG CONTAMINANT MIGRATION PATHWAYS
FORMER FIRESTONE FACILITY
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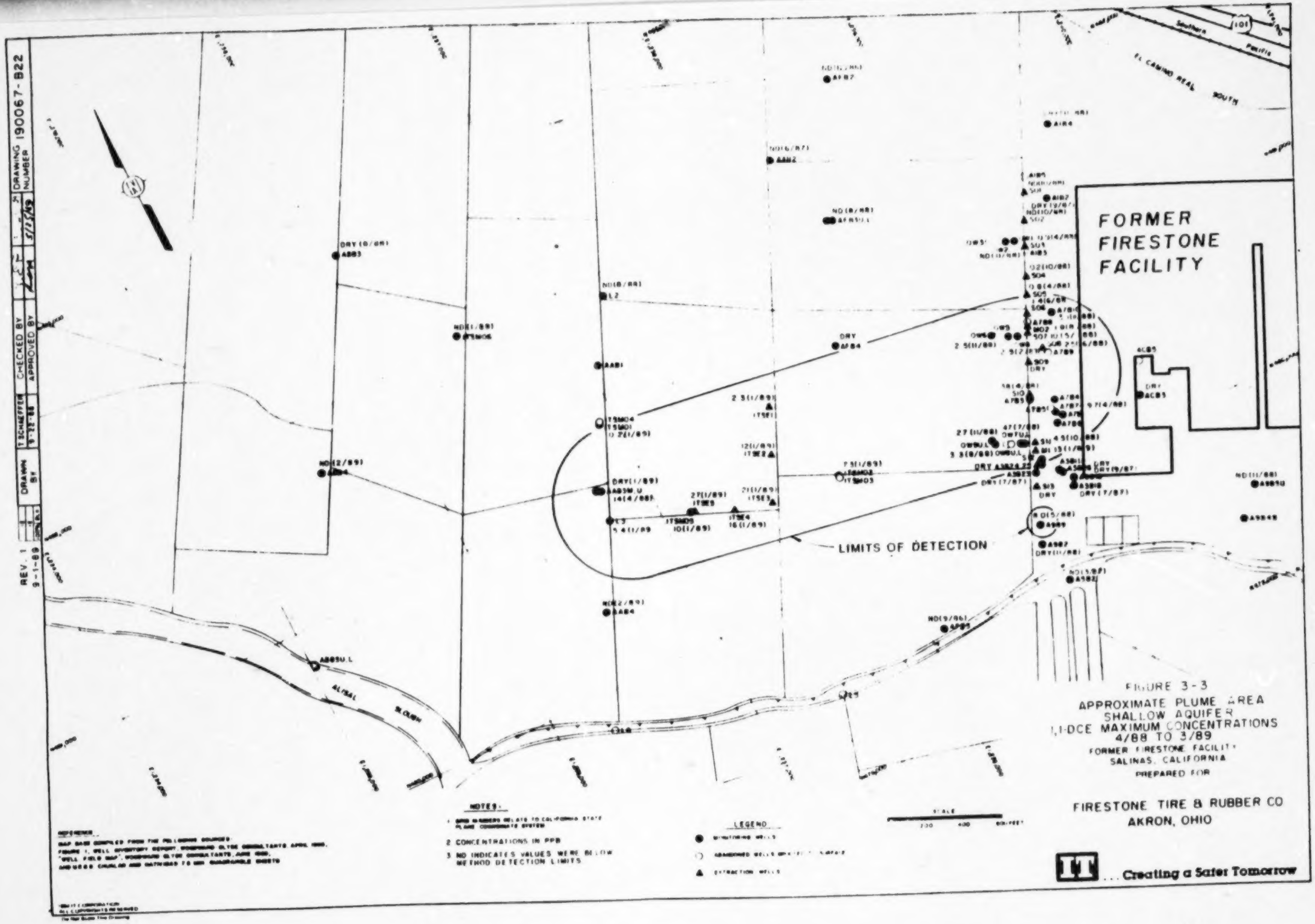
FORMER FIRESTONE FACILITY
LIMITS OF DETECTION
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
DRY
ND(2/89)
ND(8/88)
ND(6/87)
ND(1/89)
DRY(8/88)
DRY(1/89)
14(4/88)
5.4(1/89)
10(1/89)
16(1/89)
27(1/89)
2.5(1/89)
12(1/89)
7.5(1/89)
2.5(11/88)
27(11/88)
3.3(8/88)
47(7/88)
4.5(10/88)
9.7(4/88)
ND(9/86)
ND(3/87)
ND(11/88)
DRY(7/87)
DRY(9/87)
DRY(11/88)
A8E5U.L
LEGEND
MONITORING WELLS
ABANDONED WELLS
EXTRACTION WELLS
SCALE
200
400
800 FEET

NOTES:

1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM

2 CONCENTRATIONS IN PPB

3 ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS

FIGURE 3-3

APPROXIMATE PLUME AREA
SHALLOW AQUIFER
1,1-DCE MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

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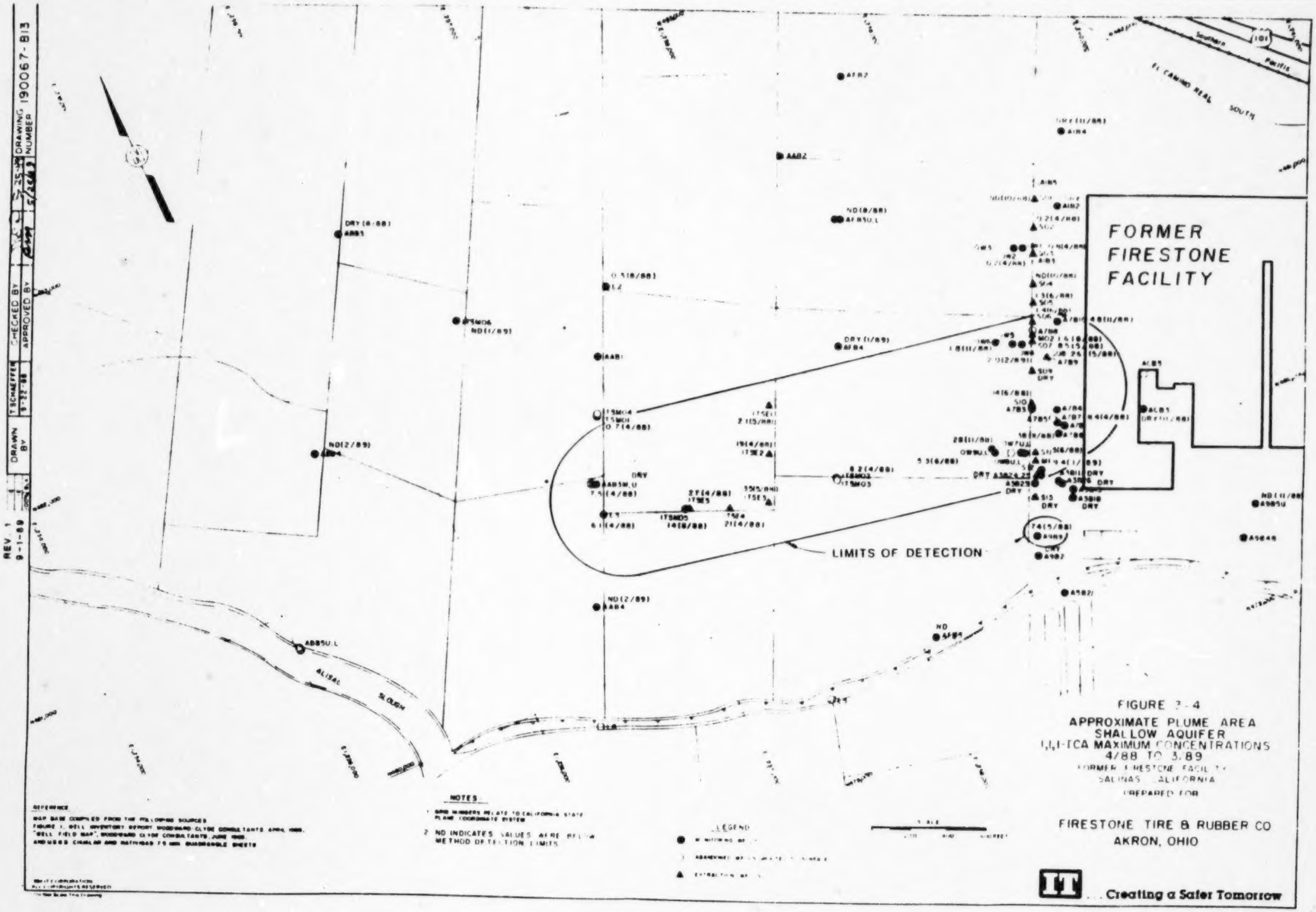
FORMER FIRESTONE FACILITY
LIMITS OF DETECTION
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
DRY (11/88)
AIR4
AFR2
AAB2
ND (8/88)
AFR5U,L
DRY (6/88)
ABB3
0.5 (8/88)
L4
ITSMO6
ND (1/89)
AAB1
DRY (1/89)
AFR4
ND (2/89)
ABB4
ND (2/89)
AAB4
ITSMO4
ITSMO1
0.7 (4/88)
DRY
AAB5M,U
7.5 (4/88)
6.1 (4/88)
2.7 (4/88)
ITSE5
ITSMO5
14 (8/88)
ITSE4
21 (4/88)
2.1 (5/88)
ITSE1
19 (4/88)
ITSE2
35 (5/88)
ITSE3
8.2 (4/88)
ITSMO2
ITSMO3
5.5 (6/88)
28 (11/88)
74 (5/88)
A9B3
DRY
A9B2
A5B2
ND
AFB5
ND (11/88)
A9B5U
A5B4S
AFB5U,L
ABB5U,L
ALB5
DRY (11/88)
ALB1

NOTES

1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM

2 ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS

REFERENCE

MAP BASE COMPILED FROM THE FOLLOWING SOURCES
FIGURE 1, WELL INVENTORY REPORT WOODWARD-CLYDE CONSULTANTS APRIL 1988.
"WELL FIELD MAP", WOODWARD CLYDE CONSULTANTS, JUNE 1988.
AND USGS CHUALAR AND NATIVIDAD 7.5 MIN QUADRANGLE SHEETS

LEGEND

● MONITORING WELL

▲ EXTRACTION WELL

SCALE

FIGURE 3-4
APPROXIMATE PLUME AREA
SHALLOW AQUIFER
1,1,1-TCA MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

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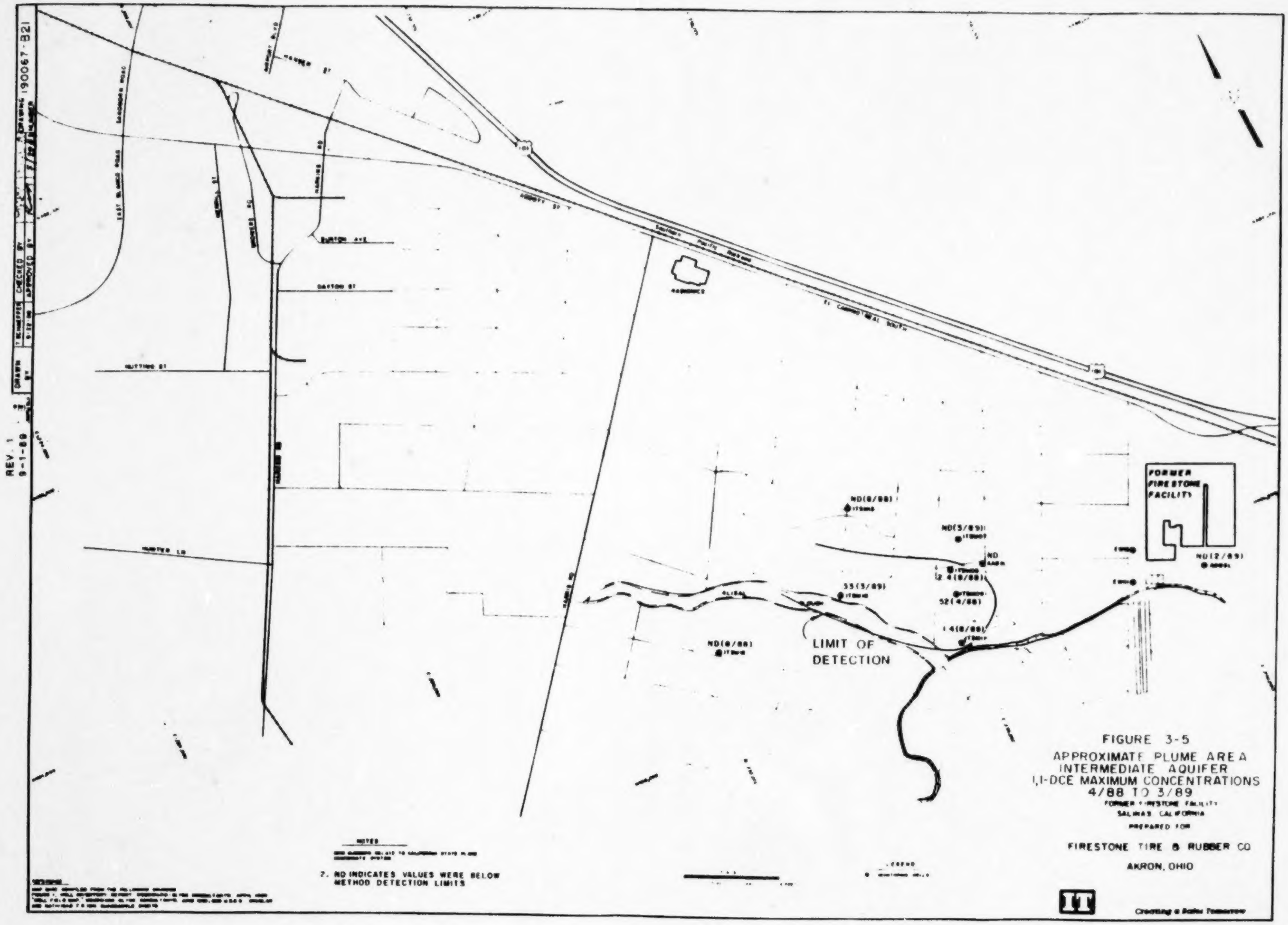
FORMER
FIRESTONE
FACILITY
ND(2/89)
ND(8/88)
ND(3/89)
ND
2.4(8/88)
33(3/89)
52(4/88)
1.4(8/88)
ND(8/88)
LIMIT OF
DETECTION
Southern Pacific Railroad
BURTON AVE
DAYTON ST
HARRIS RD
HARDER ST
AIRPORT BLVD
EAST BLANCO ROAD
SANBORN ROAD
HUTTING ST
HUNTER LN
NOTES
LEGEND
REV. 1
9-1-89
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IT
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FIGURE 3-5

APPROXIMATE PLUME AREA
INTERMEDIATE AQUIFER
1,1-DCE MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

2. ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS

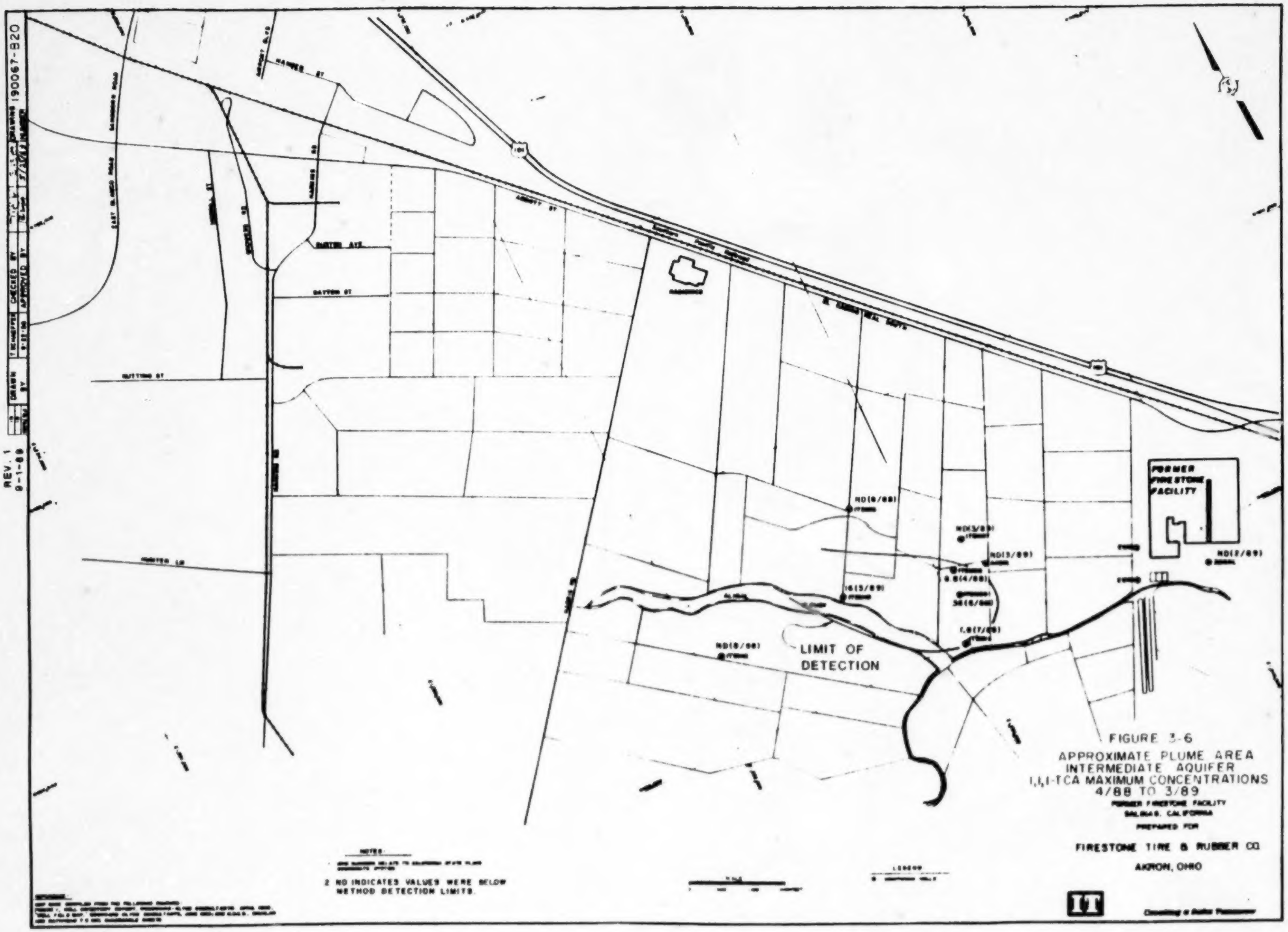
FORMER FIRESTONE FACILITY
ND(2/89)
ND(3/89)
ND(3/89)
6.8(4/88)
38(6/88)
1.6(7/88)
ND(6/88)
16(3/89)
ND(6/88)
LIMIT OF DETECTION
DAYTON ST
GUTTING ST
ABBOTT ST
AIRPORT BLVD
IT

FIGURE 3-6

APPROXIMATE PLUME AREA
INTERMEDIATE AQUIFER
1,1,1-TCA MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

NOTES:

2 ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS.

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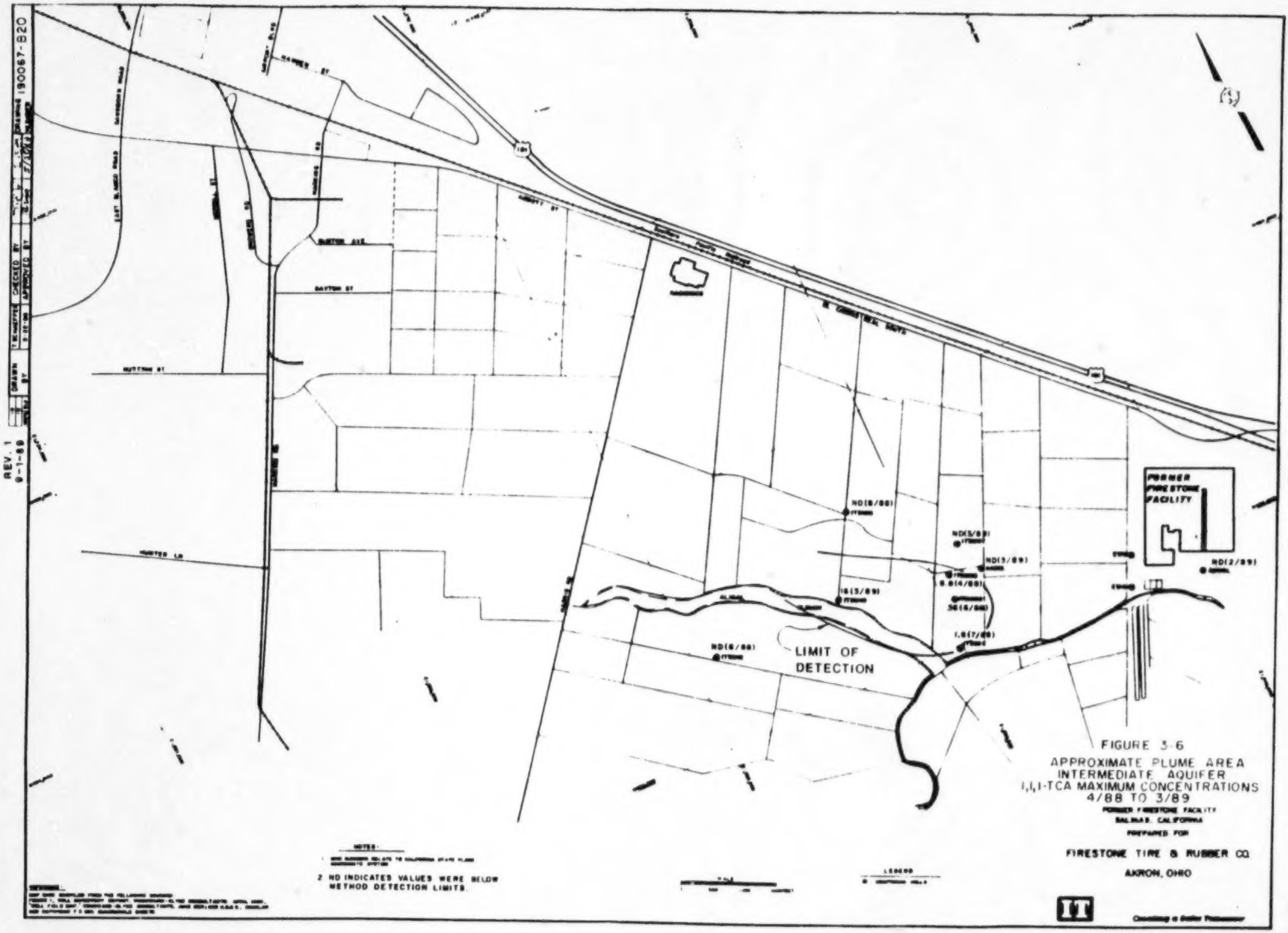
REV. 1
9-1-89


FORMER
FIRESTONE
FACILITY
ND(2/89)
ND(3/89)
ND(3/89)
9.0(4/88)
36(6/88)
1.6(7/88)
ND(8/88)
16(3/89)
ND(6/88)
LIMIT OF
DETECTION
DAYTON ST
101
LEGEND
SCALE

NOTES:

1 [illegible]

2 ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS.

FIGURE 3-6

APPROXIMATE PLUME AREA
INTERMEDIATE AQUIFER
1,1,1-TCA MAXIMUM CONCENTRATIONS
4/88 TO 3/89

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

PREPARED FOR

FIRESTONE TIRE & RUBBER CO.

AKRON, OHIO

IT

REV. 1
9-1-89

DRAWN BY | CHECKED BY | APPROVED BY | DRAWING NUMBER 190067-B20

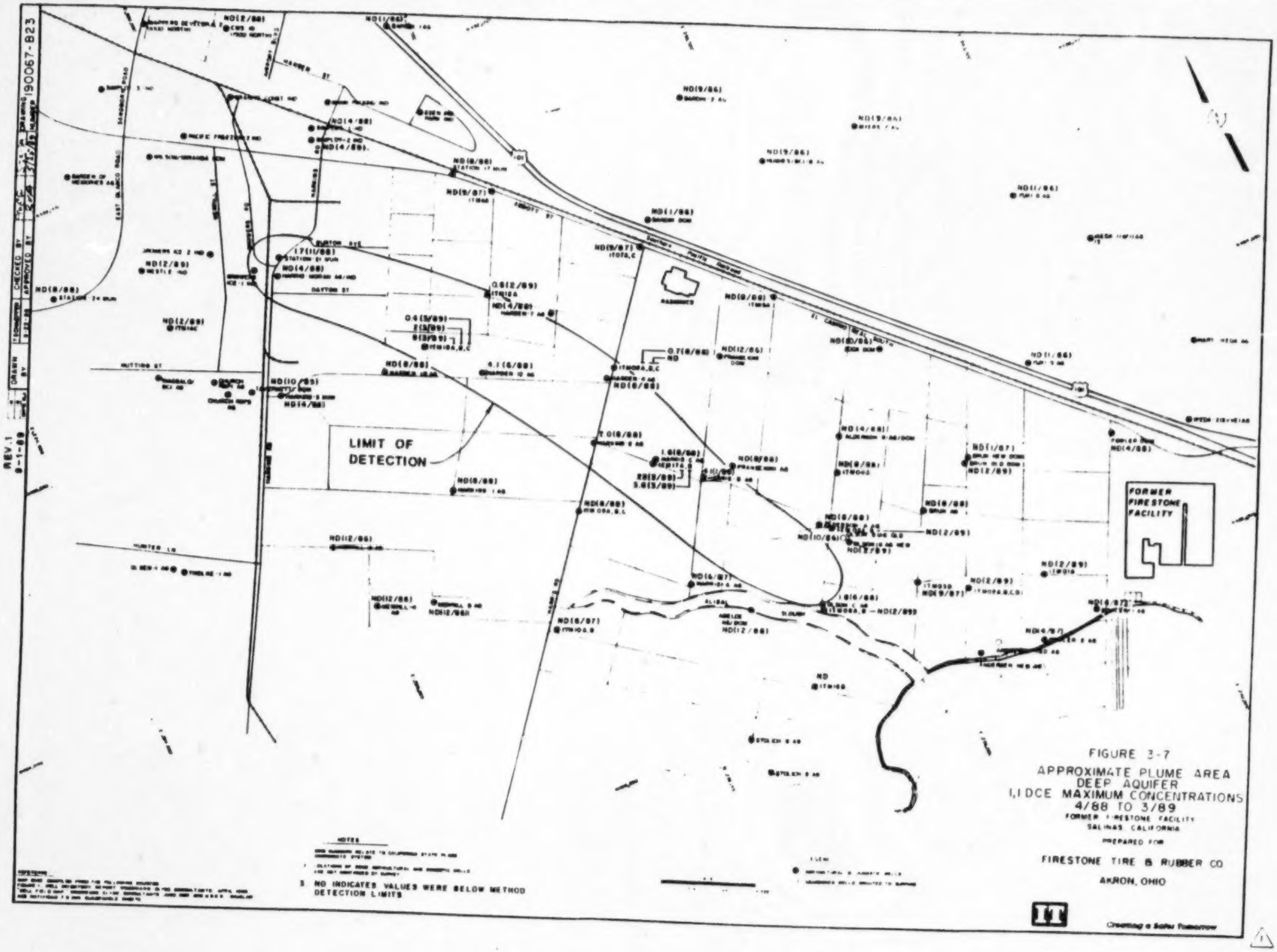

FORMER FIRESTONE FACILITY
LIMIT OF DETECTION
101
ND(9/86)
ND(1/86)
ND(9/87)
ND(8/88)
ND(4/88)
ND(2/89)
ND(12/88)
ND(10/88)
ND(14/88)
1.7(11/88)
0.6(2/89)
0.4(3/89)
4.1(6/88)
0.7(6/88)
7.0(6/88)
1.6(6/88)
ND(6/87)
ND(1/87)
ND(4/87)
EL CAMINO REAL
DAYTON ST
HUTTON ST
EAST BLANCO ROAD
ABBOTT ST
BURTON AVE
NOTES
LEGEND

FIGURE 3-7

APPROXIMATE PLUME AREA
DEEP AQUIFER
1,1DCE MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

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AKRON, OHIO

IT

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3. ND INDICATES VALUES WERE BELOW METHOD DETECTION LIMITS

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REV.1
9-1-89

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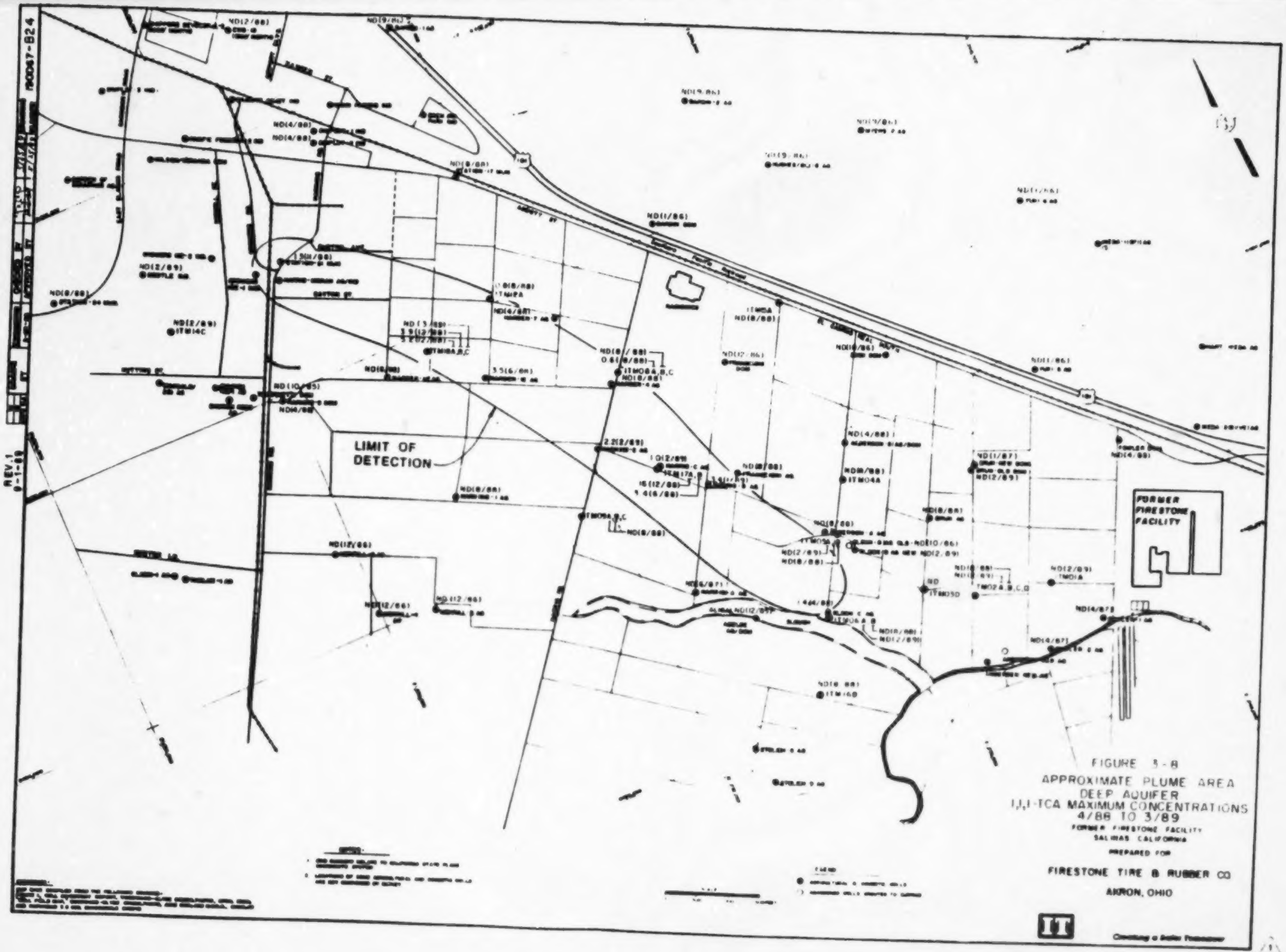
FORMER FIRESTONE FACILITY
LIMIT OF DETECTION
ND(1/86)
ND(9/86)
ND(2/89)
ND(8/88)
ND(4/88)
ND(12/86)
ND(10/85)
ND(8/88)
ND(4/87)
ND(2/89)
ND(12/89)
ND(1/87)
ND(4/88)
ND(6/87)
ND(12/86)
1.5(6/88)
1.0(8/88)
0.6(8/88)
ITM08A,B,C
ITM04A
ITM01A
ITM05D
ITM02A,B,C,D
ITM05A,B,C
ITM14C
ITM16D
2.2(2/89)
10(2/89)
16(12/88)
1.4(6/88)
3.5(6/88)
14.4(4/88)
REV.1
9-1-89
790067-B24

FIGURE 3-8

APPROXIMATE PLUME AREA
DEEP AQUIFER
1,1,1-TCA MAXIMUM CONCENTRATIONS
4/88 TO 3/89
FORMER FIRESTONE FACILITY
SALINAS CALIFORNIA

PREPARED FOR

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AKRON, OHIO

IT

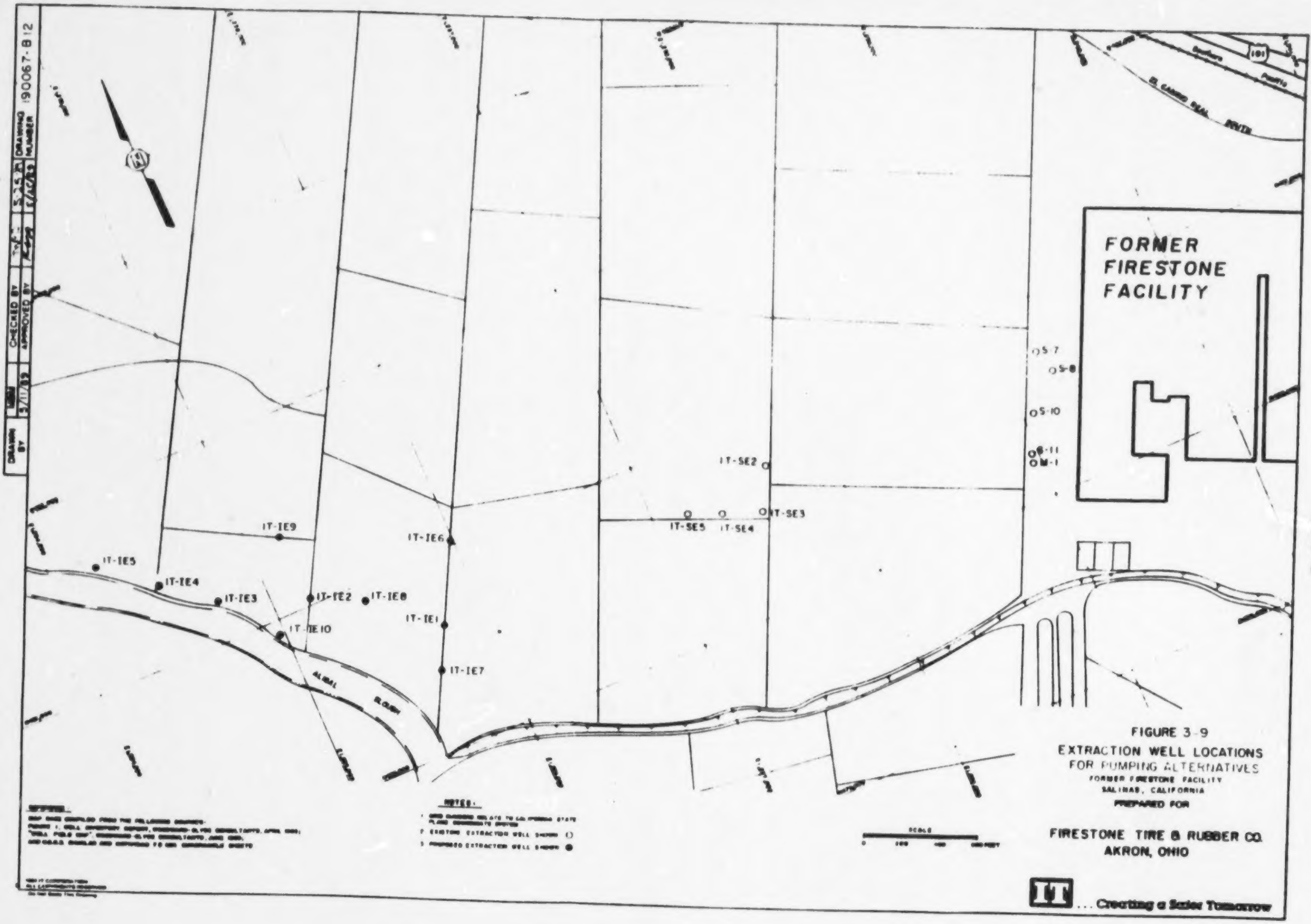
FORMER FIRESTONE FACILITY
S-7
S-8
S-10
B-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE1
IT-IE2
IT-IE3
IT-IE4
IT-IE5
IT-IE6
IT-IE7
IT-IE8
IT-IE9
IT-IE10
101
EL CAMINO REAL SOUTH
NOTES:
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
SCALE
DRAWN BY
5/11/89
CHECKED BY
APPROVED BY
DRAWING NUMBER
190067-B12
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FIGURE 3-9
EXTRACTION WELL LOCATIONS
FOR PUMPING ALTERNATIVES
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

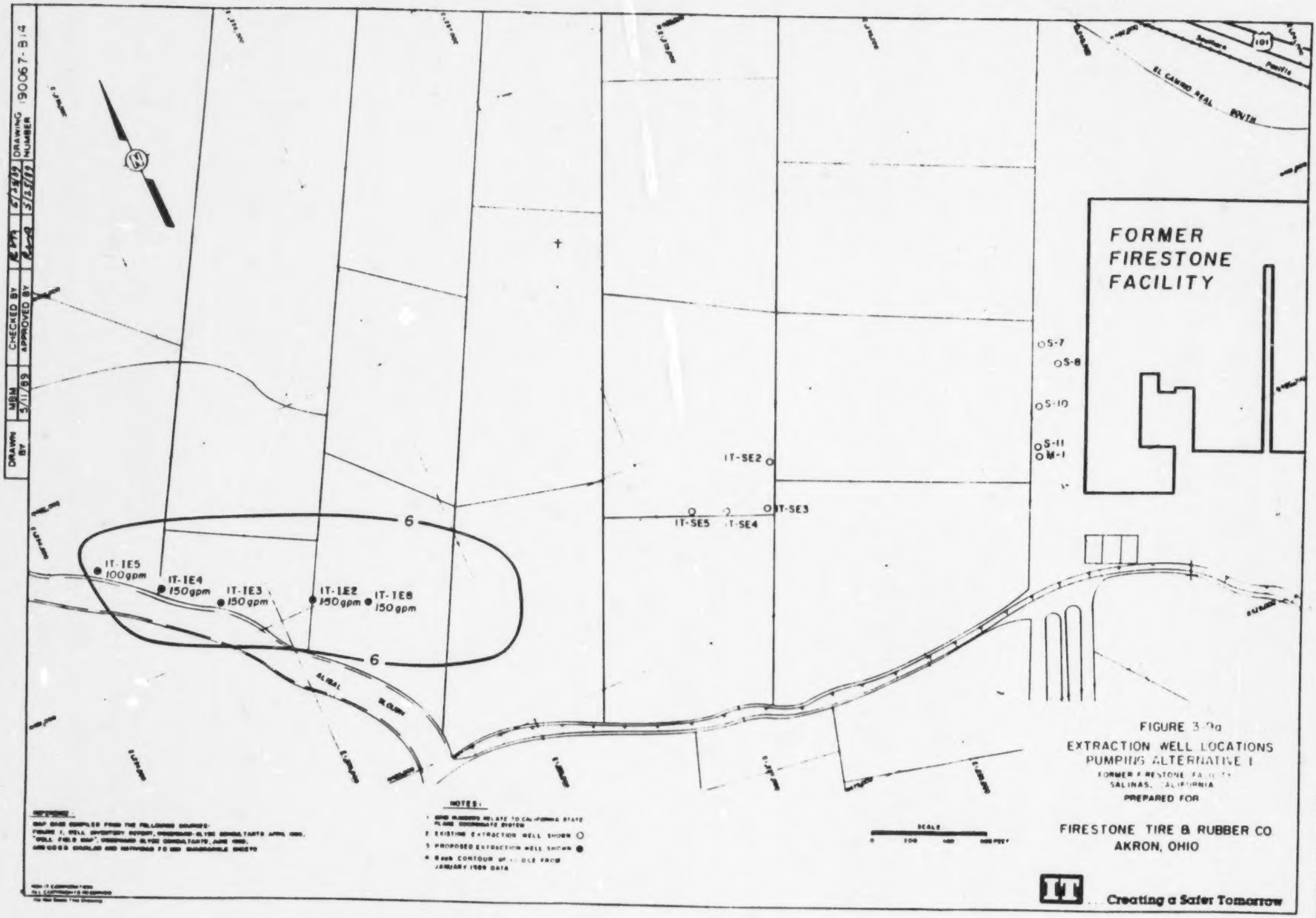
FORMER
FIRESTONE
FACILITY
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE5 100gpm
IT-IE4 150gpm
IT-IE3 150gpm
IT-IE2 150gpm
IT-IE8 150gpm
6
6
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
SCALE
0
N

FIGURE 3-9a
EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE I
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

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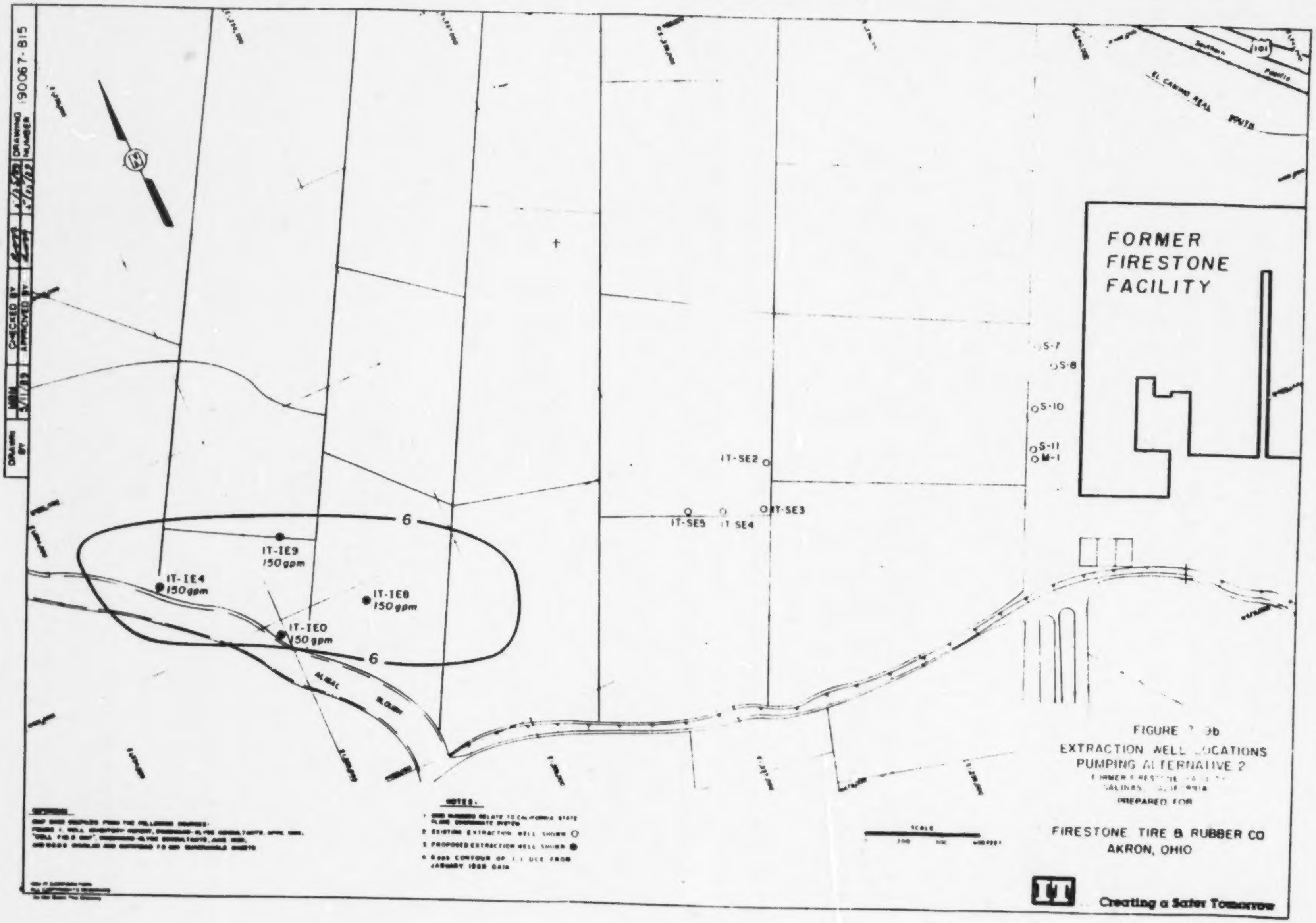
NOTES:

1. GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2. EXISTING EXTRACTION WELL SHOWN ○
3. PROPOSED EXTRACTION WELL SHOWN ●
4. 6 ppb CONTOUR OF [illegible] DCE FROM JANUARY 1989 DATA

REFERENCE:

MAP BASE COMPILED FROM THE FOLLOWING SOURCES:
[illegible]

DRAWN BY	MBM	CHECKED BY	[illegible]	5/29/89	DRAWING NUMBER	190067-B14
	5/11/89	APPROVED BY	[illegible]	5/31/89		


FORMER
FIRESTONE
FACILITY
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE9
150 gpm
IT-IE4
150 gpm
IT-IE8
150 gpm
IT-IE0
150 gpm
6
6
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
SCALE
DRAWN BY
NBM
3/11/89
CHECKED BY
APPROVED BY
DRAWING NUMBER
190067-B15

NOTES:

1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
4 6 ppb CONTOUR OF 1,1 DCE FROM JANUARY 1989 DATA

FIGURE ? 9b
EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE 2
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
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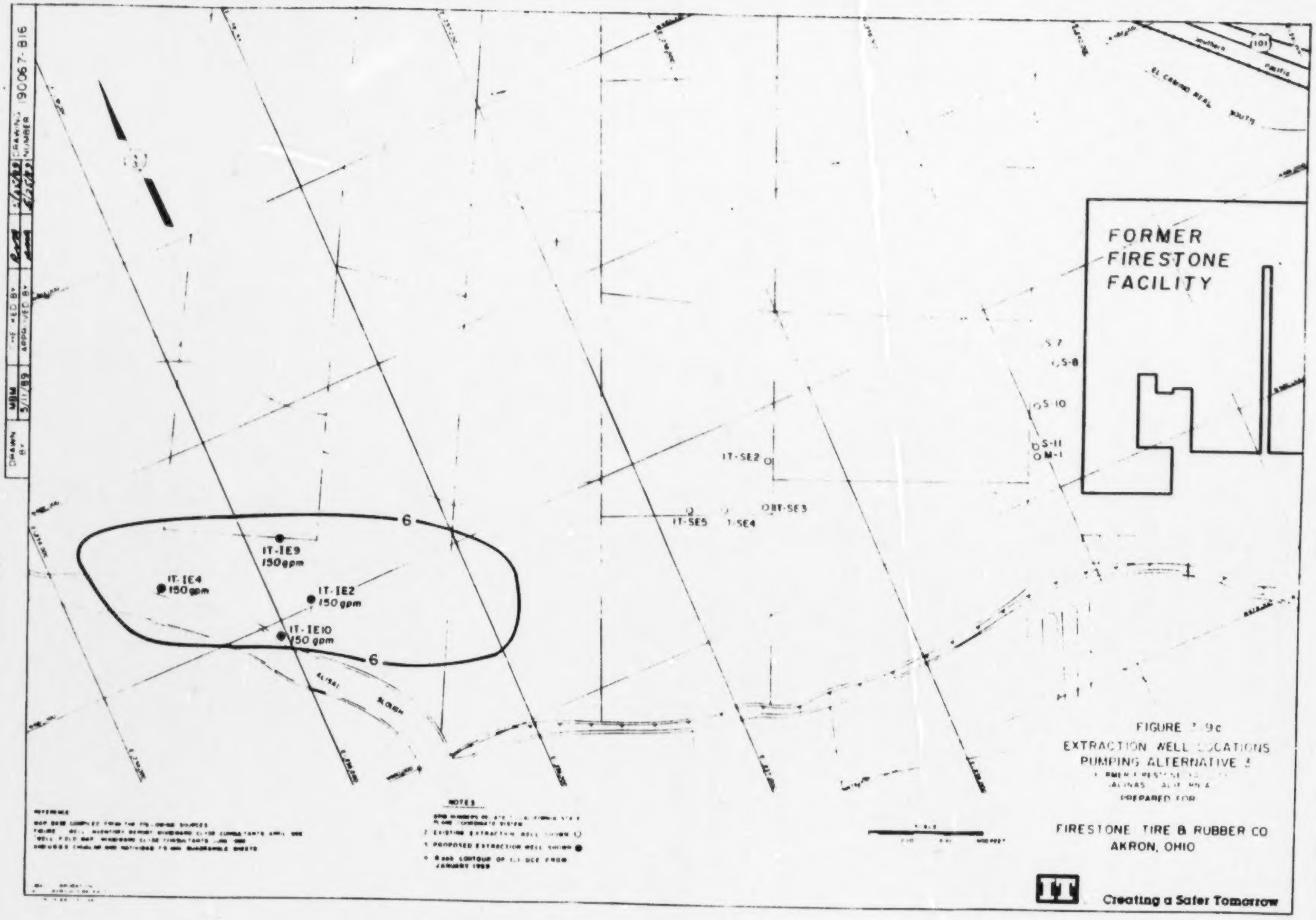
FORMER
FIRESTONE
FACILITY
EL CAMINO REAL SOUTH
101
SOUTHERN PACIFIC
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE5
T-SE4
OBT-SE3
IT-IE9
150 gpm
IT-IE4
150 gpm
IT-IE2
150 gpm
IT-IE10
150 gpm
6
6
ALISAL SLOUGH
NOTES
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
4 CONTOUR OF 1,1 DCE FROM JANUARY 1989

FIGURE 7-9c
EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE 3
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO
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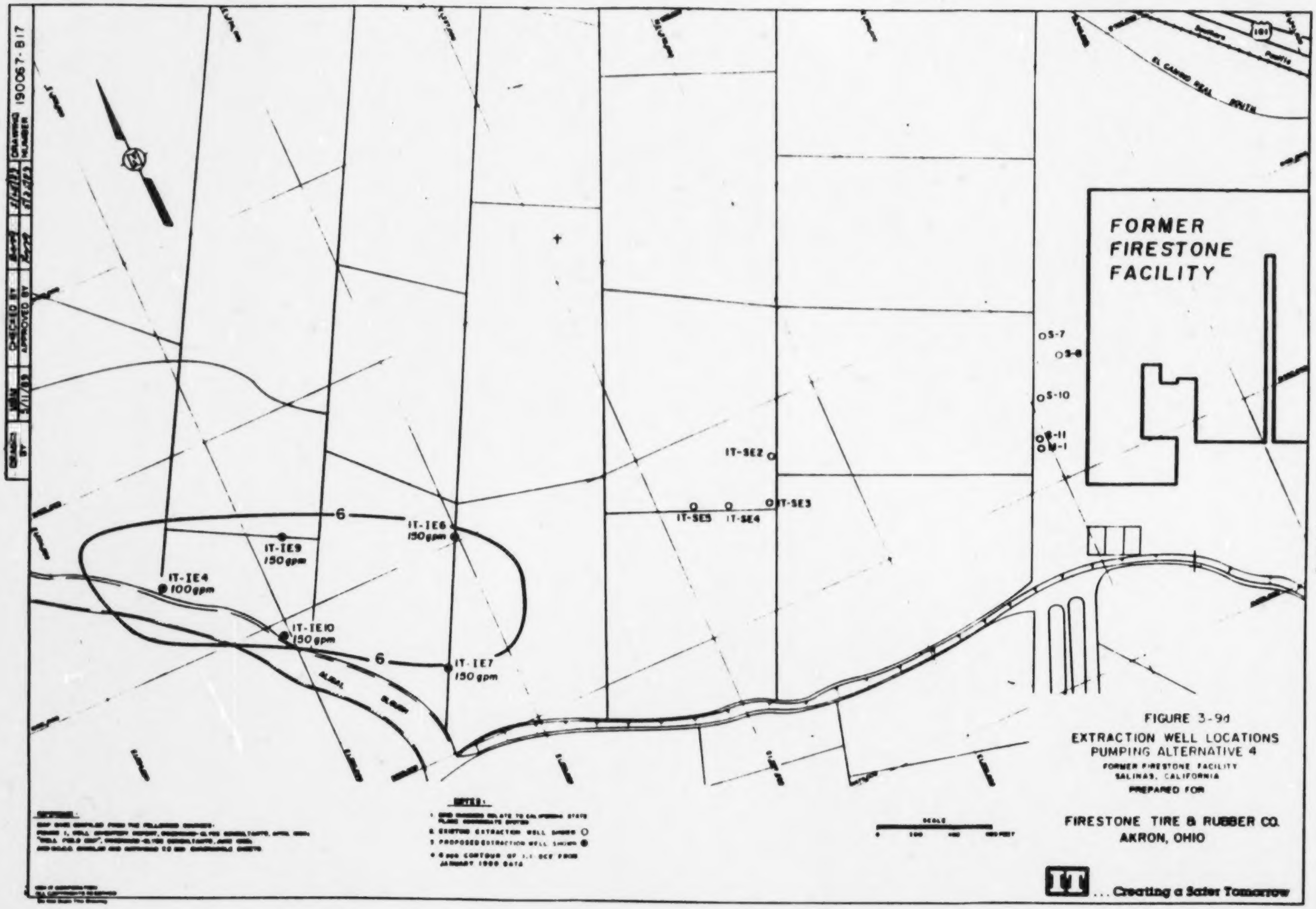
	5/11/89	APPROVED BY			


FORMER FIRESTONE FACILITY
101
EL CAMINO REAL SOUTH
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE4 100gpm
IT-IE6 150gpm
IT-IE7 150 gpm
IT-IE9 150 gpm
IT-IE10 150gpm
6
NOTES:
1 GRID [illegible] RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
4 6 ppb CONTOUR OF 1,1 DCE FROM JANUARY 1990 DATA
SCALE
DRAWN BY
CHECKED BY
APPROVED BY
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DRAWING NUMBER 190067-B17

FIGURE 3-9d
EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE 4
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
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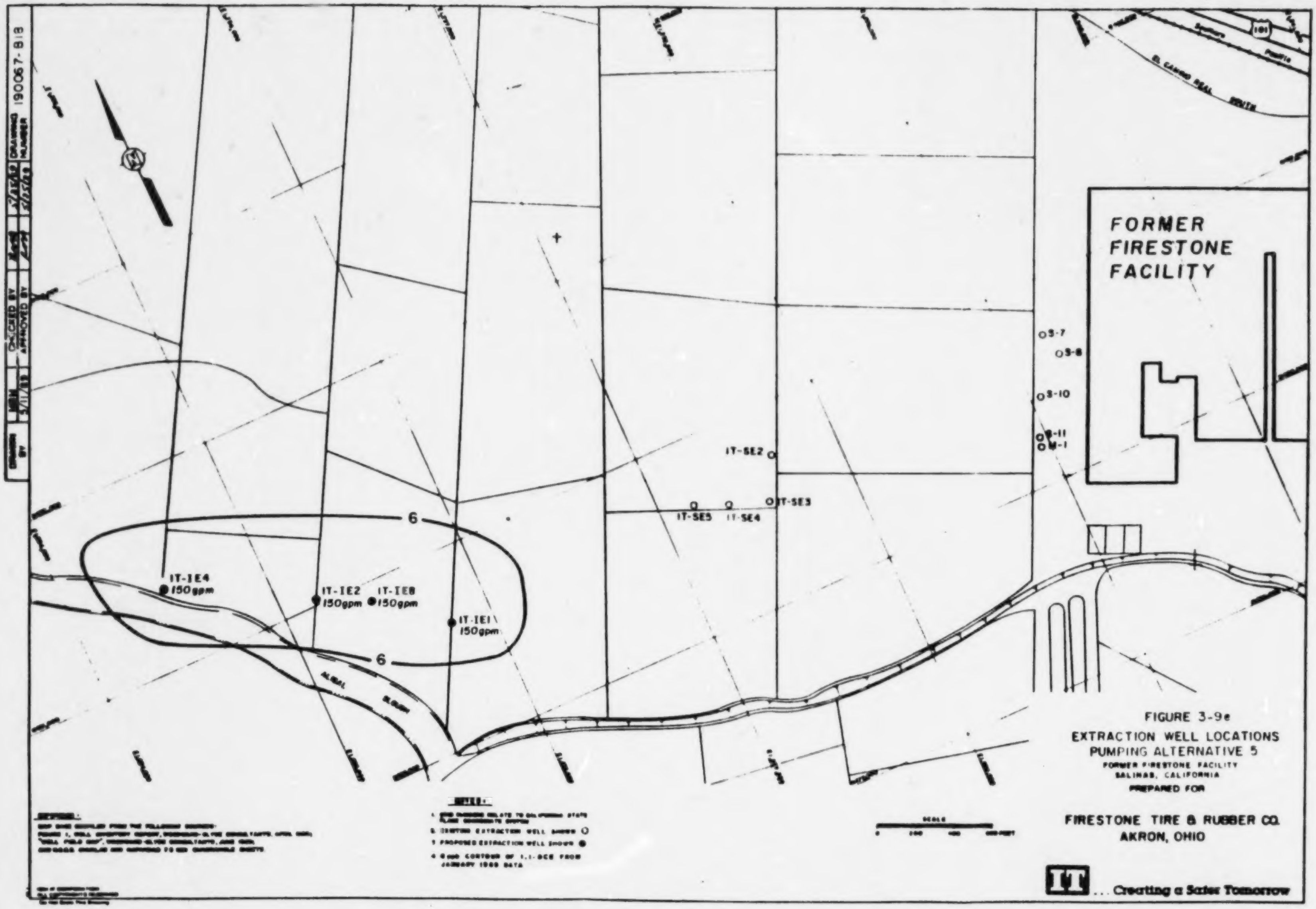
FORMER FIRESTONE FACILITY
EL CAMINO REAL SOUTH
Southern Pacific
101
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE1 150gpm
IT-IE2 150gpm
IT-IE8 150gpm
IT-IE4 150gpm
6
6
ALISAL SLOUGH
SCALE
DRAWN BY MBM 5/11/89
CHECKED BY
APPROVED BY
DRAWING NUMBER 190067-B18

NOTES:

1. [illegible] RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2. EXISTING EXTRACTION WELL SHOWN ○
3. PROPOSED EXTRACTION WELL SHOWN ●
4. 6 ppb CONTOUR OF 1,1-DCE FROM JANUARY 1989 DATA

FIGURE 3-9e

EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE 5
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
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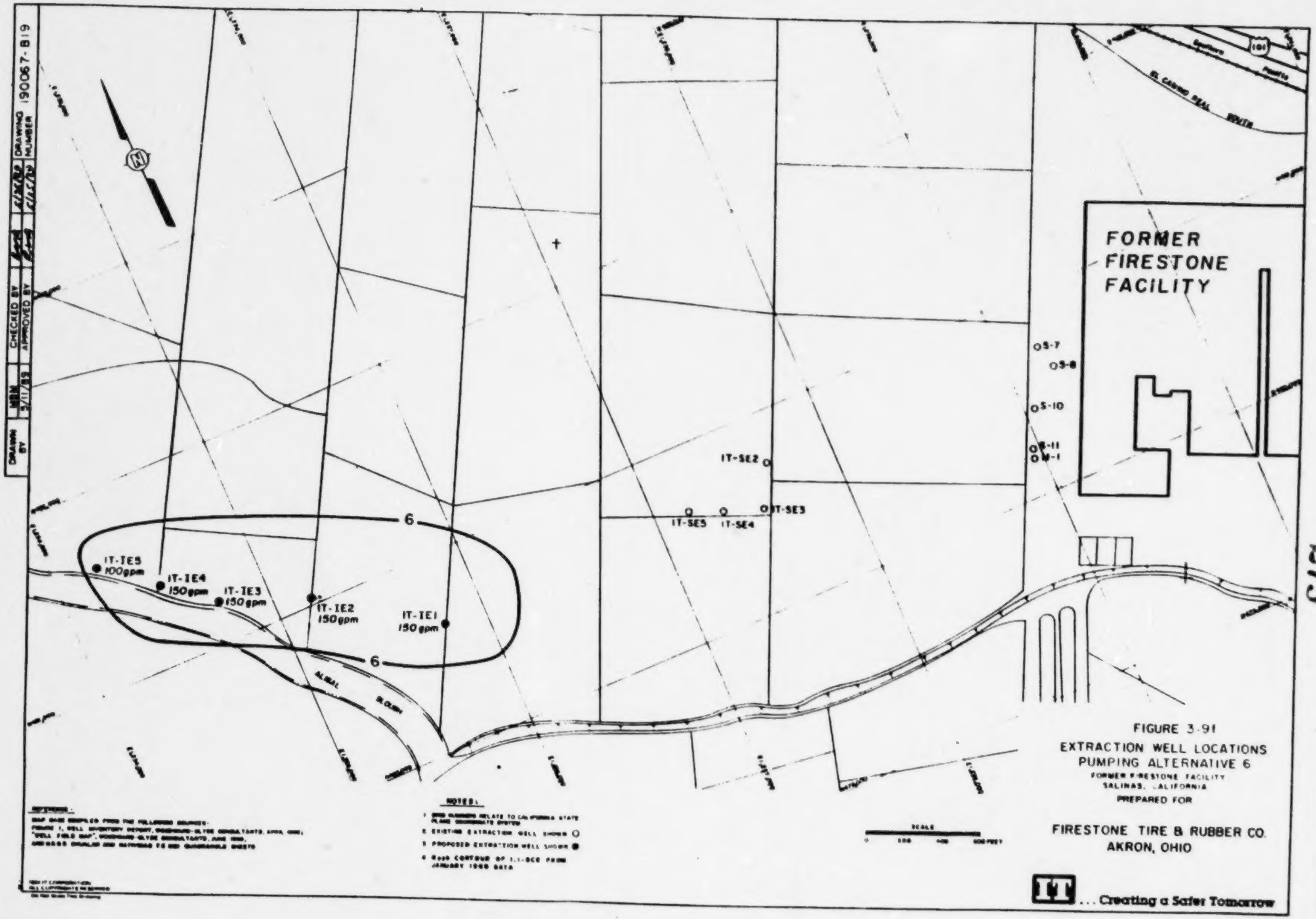
FORMER FIRESTONE FACILITY
EL CAMINO REAL SOUTH
101
OS-7
OS-8
OS-10
OS-11
OW-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE1 150gpm
IT-IE2 150gpm
IT-IE3 150gpm
IT-IE4 150gpm
IT-IE5 100gpm
6
6
ALISAL SLOUGH
N
SCALE
0 200 400 800 FEET

FIGURE 3-91
EXTRACTION WELL LOCATIONS
PUMPING ALTERNATIVE 6
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR
FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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NOTES:
1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
4 6 ppb CONTOUR OF 1,1-DCE FROM JANUARY 1989 DATA

REFERENCE:
MAP BASE COMPILED FROM THE FOLLOWING SOURCES:
FIGURE 1, WELL INVENTORY REPORT, WOODWARD-CLYDE CONSULTANTS, [illegible];
"WELL FIELD MAP", WOODWARD-CLYDE CONSULTANTS, [illegible].
AND U.S.G.S. CHUALAR AND NATIVIDAD 7.5 MIN QUADRANGLE SHEETS

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	5/11/89	APPROVED BY		

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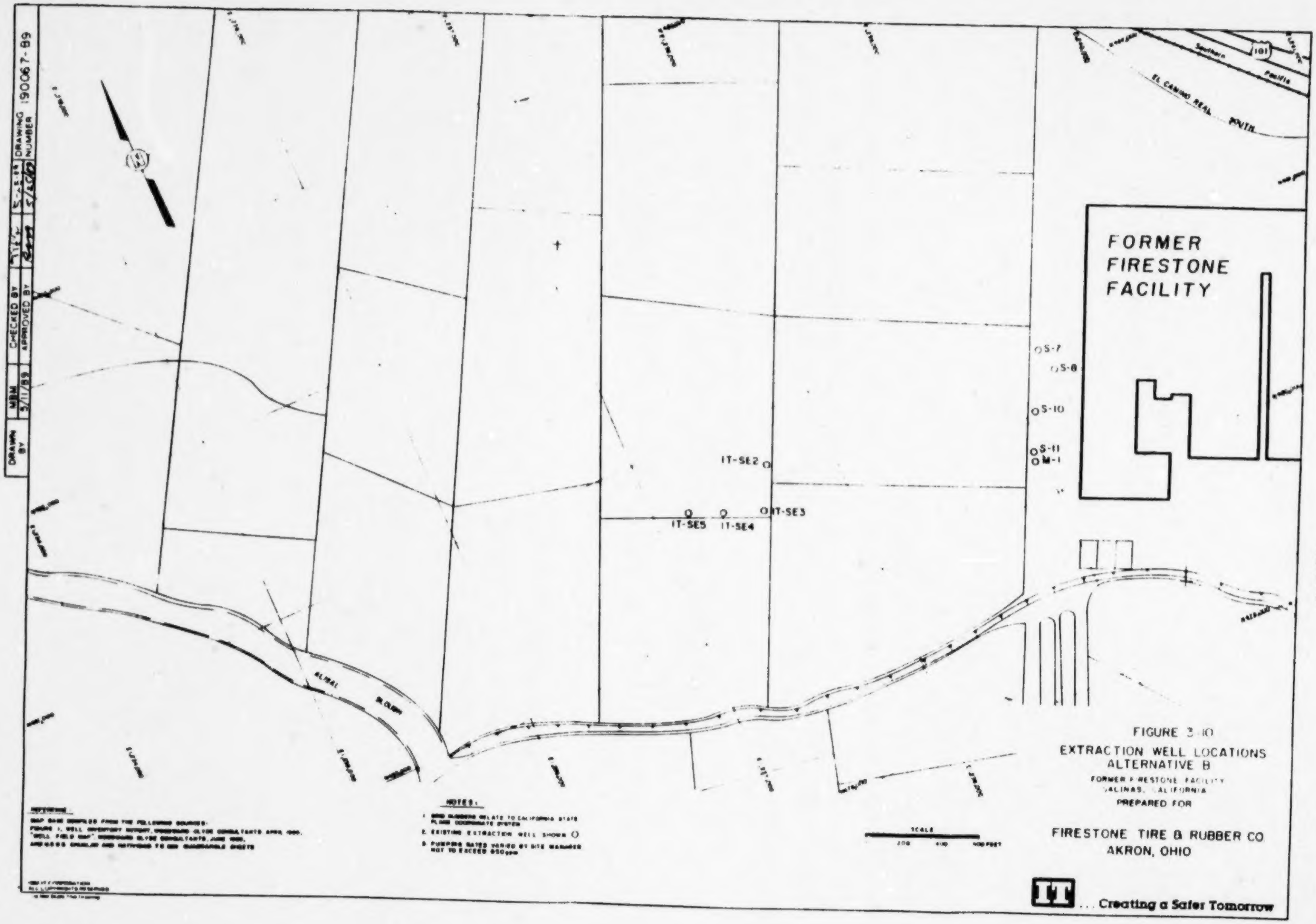
FORMER
FIRESTONE
FACILITY
OS-7
OS-8
OS-10
OS-11
OM-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
101
Southern Pacific
EL CAMINO REAL SOUTH
ALISAL SLOUGH
SCALE
200
400
NOTES:
2. EXISTING EXTRACTION WELL SHOWN ○
3. PUMPING RATES VARIED BY SITE MANAGER NOT TO EXCEED 650gpm

FIGURE 3-10

EXTRACTION WELL LOCATIONS
ALTERNATIVE B

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

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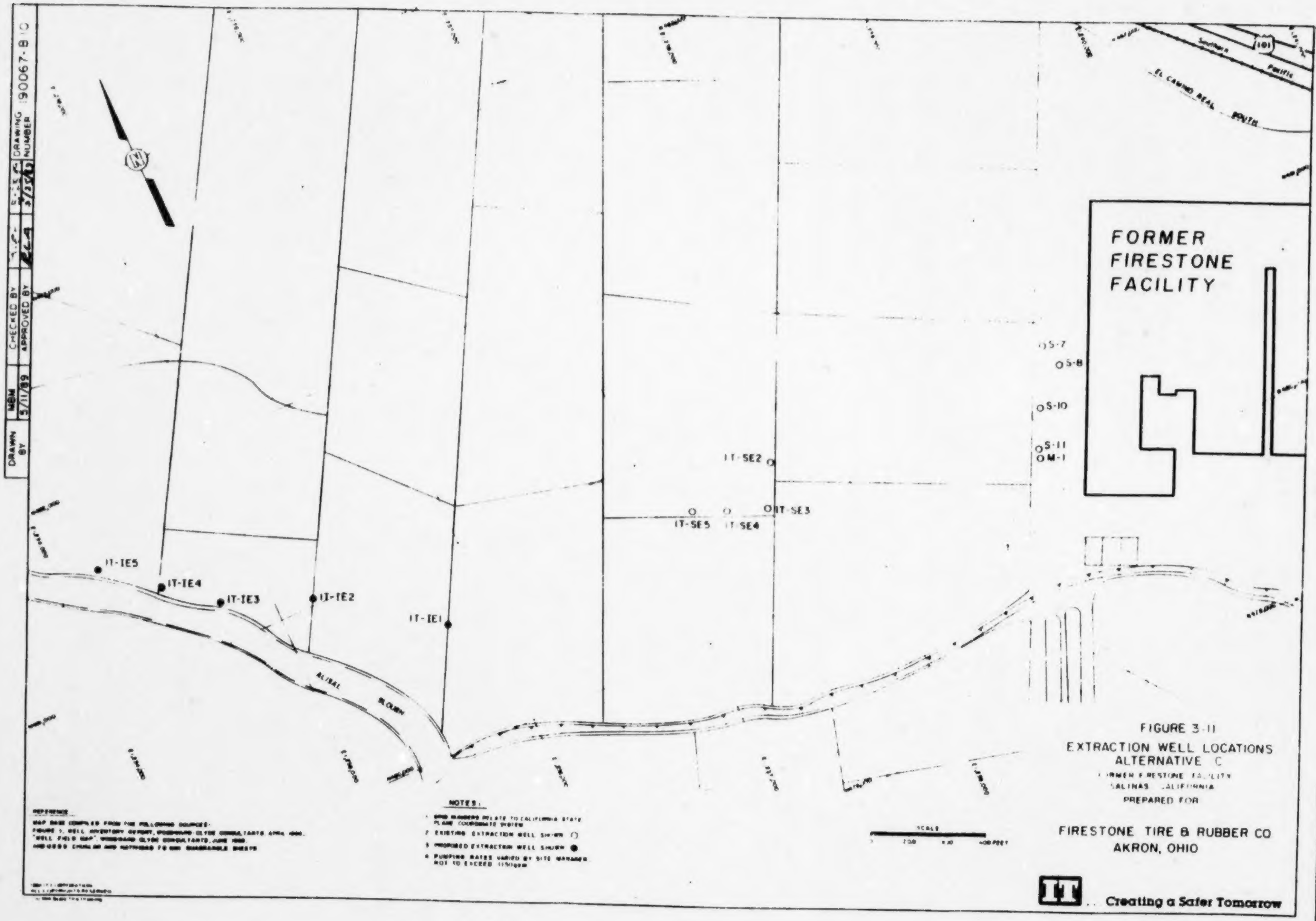
	5/11/89	APPROVED BY		5/25/89	


FORMER FIRESTONE FACILITY
S-7
S-8
S-10
S-11
M-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE1
IT-IE2
IT-IE3
IT-IE4
IT-IE5
N
101
Southern Pacific
EL CAMINO REAL SOUTH
ALISAL SLOUGH
SCALE
0
200
400
400 FEET

REFERENCE
MAP BASE COMPILED FROM THE FOLLOWING SOURCES:
FIGURE 1, WELL INVENTORY REPORT, WOODWARD CLYDE CONSULTANTS [illegible]
"WELL FIELD MAP", WOODWARD CLYDE CONSULTANTS, JUNE [illegible]
AND USGS [illegible] QUADRANGLE SHEETS

NOTES:
1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
4 PUMPING RATES VARIED BY SITE MANAGER NOT TO EXCEED [illegible]gpm

FIGURE 3-11
EXTRACTION WELL LOCATIONS
ALTERNATIVE C
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

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AKRON, OHIO

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	5/11/89	APPROVED BY		5/25/89		

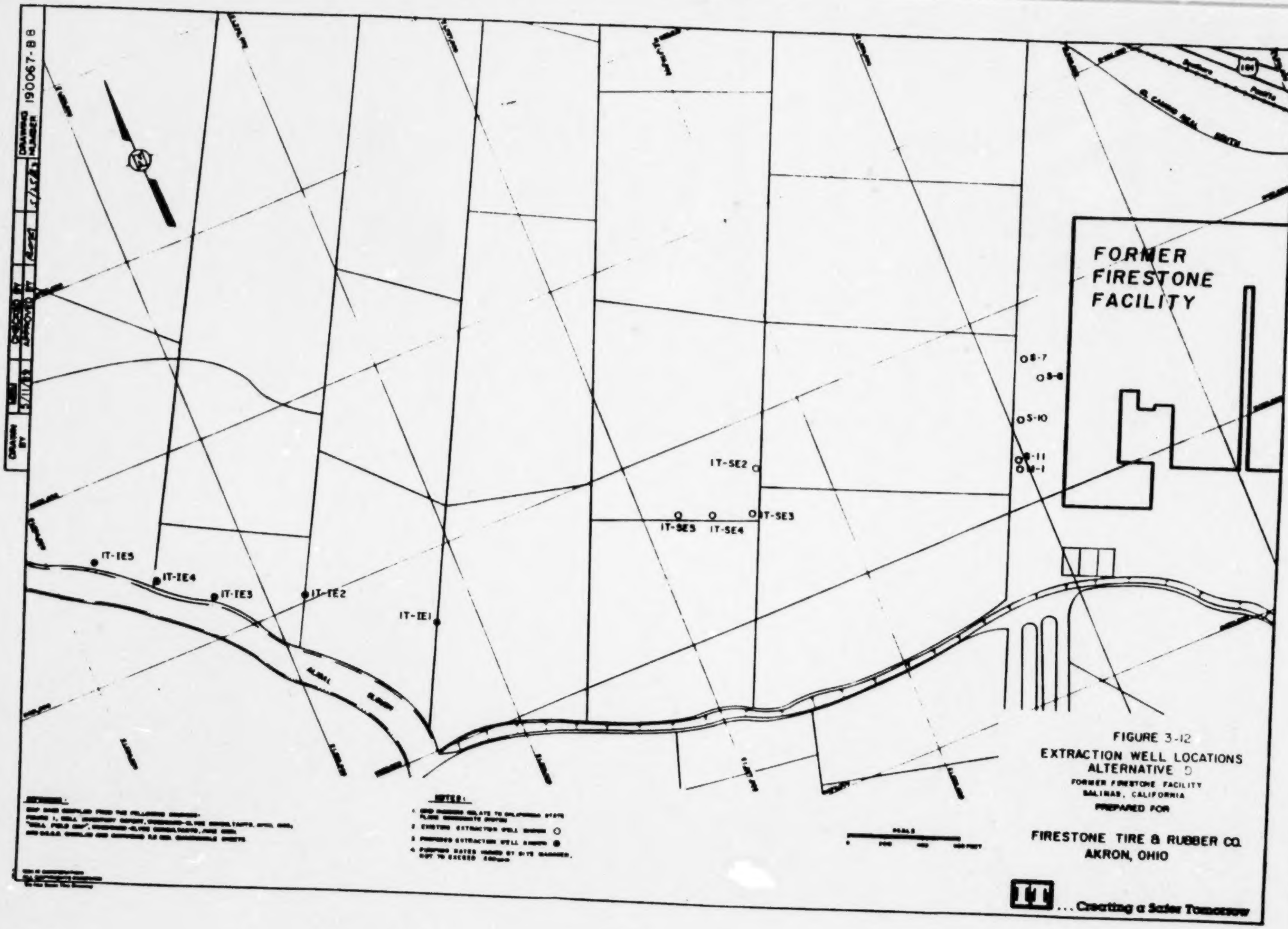
FORMER FIRESTONE FACILITY
101
EL CAMINO REAL SOUTH
O S-7
O S-8
O S-10
O S-11
O S-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-IE1
IT-IE2
IT-IE3
IT-IE4
IT-IE5
NOTES:
1. GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2. EXISTING EXTRACTION WELL SHOWN ○
3. PROPOSED EXTRACTION WELL SHOWN ●
4. PUMPING RATES VARIED BY SITE [illegible] NOT TO EXCEED [illegible]
SCALE
0
FEET
DRAWN BY
CHECKED BY
APPROVED BY
5/11/89
DRAWING NUMBER 190067-B8

FIGURE 3-12

EXTRACTION WELL LOCATIONS
ALTERNATIVE D
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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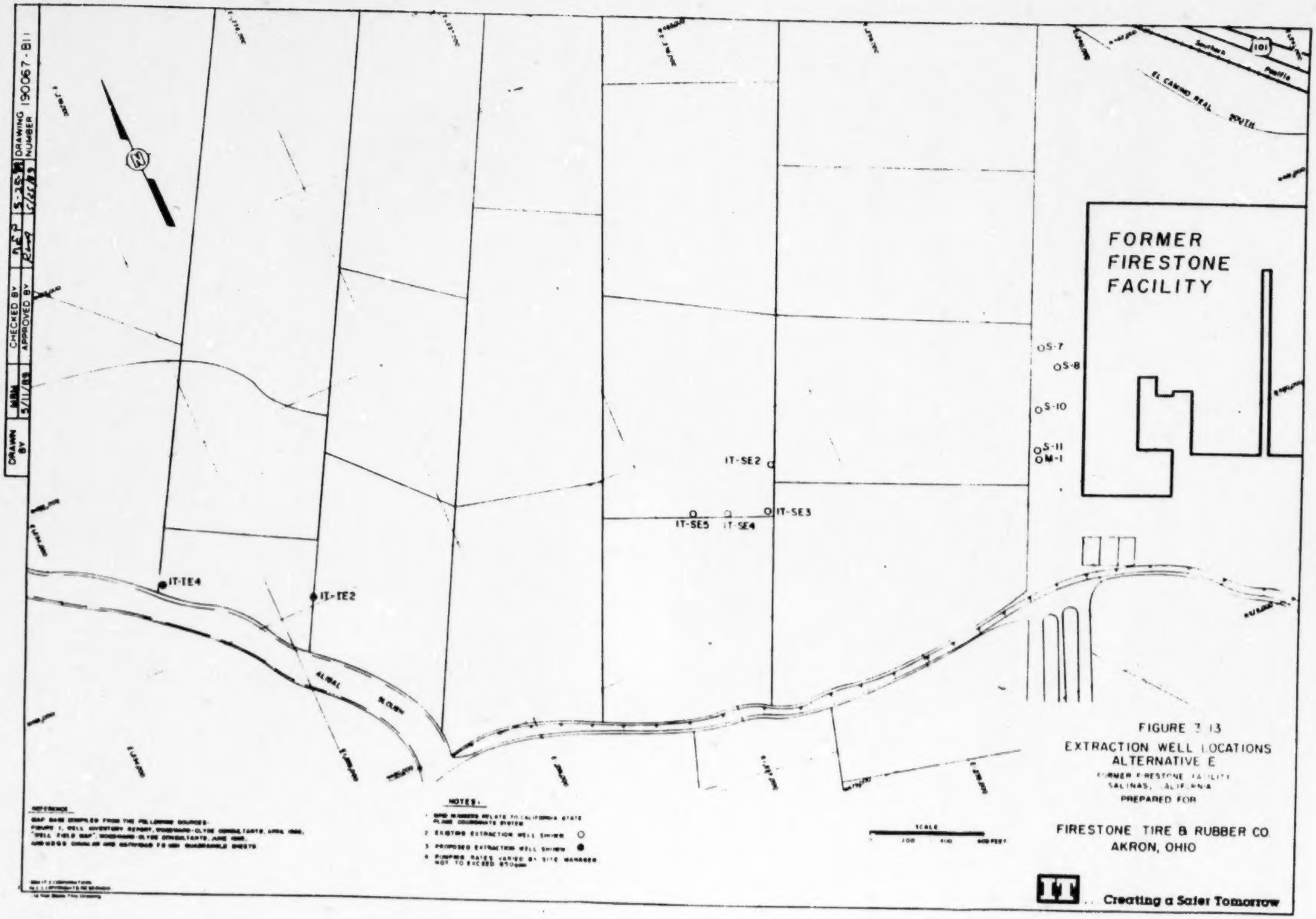
FORMER
FIRESTONE
FACILITY
OS-7
OS-8
OS-10
OS-11
OM-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
IT-TE2
IT-TE4
EL CAMINO REAL SOUTH
Southern Pacific
101
ALISAL SLOUGH
NOTES:
1 GRID NUMBERS RELATE TO CALIFORNIA STATE PLANE COORDINATE SYSTEM
2 EXISTING EXTRACTION WELL SHOWN ○
3 PROPOSED EXTRACTION WELL SHOWN ●
REFERENCE
SCALE
200
400
FEET
DRAWN BY
MBM
5/11/89
CHECKED BY
NEP
5-25-89
APPROVED BY
DRAWING NUMBER
190067-B11

FIGURE 3-13

EXTRACTION WELL LOCATIONS
ALTERNATIVE E
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
PREPARED FOR

FIRESTONE TIRE & RUBBER CO.
AKRON, OHIO

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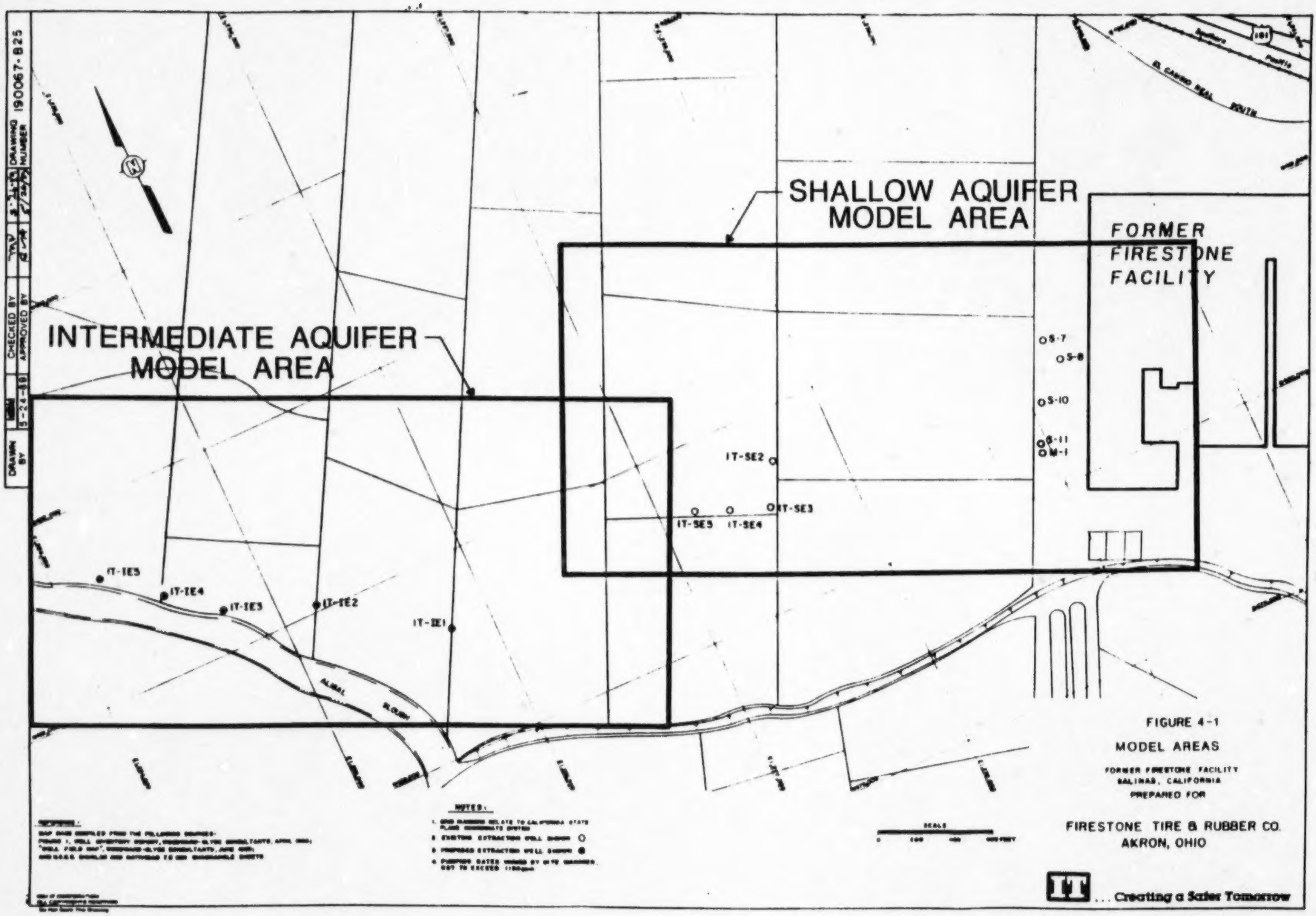
SHALLOW AQUIFER MODEL AREA
INTERMEDIATE AQUIFER MODEL AREA
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S-11
M-1
IT-SE2
IT-SE3
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SCALE
NOTES:
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PROPOSED EXTRACTION WELL SHOWN ●
DRAWN BY
5-24-89
CHECKED BY
APPROVED BY
DRAWING NUMBER 190067-B25

FIGURE 4-1

MODEL AREAS

FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA
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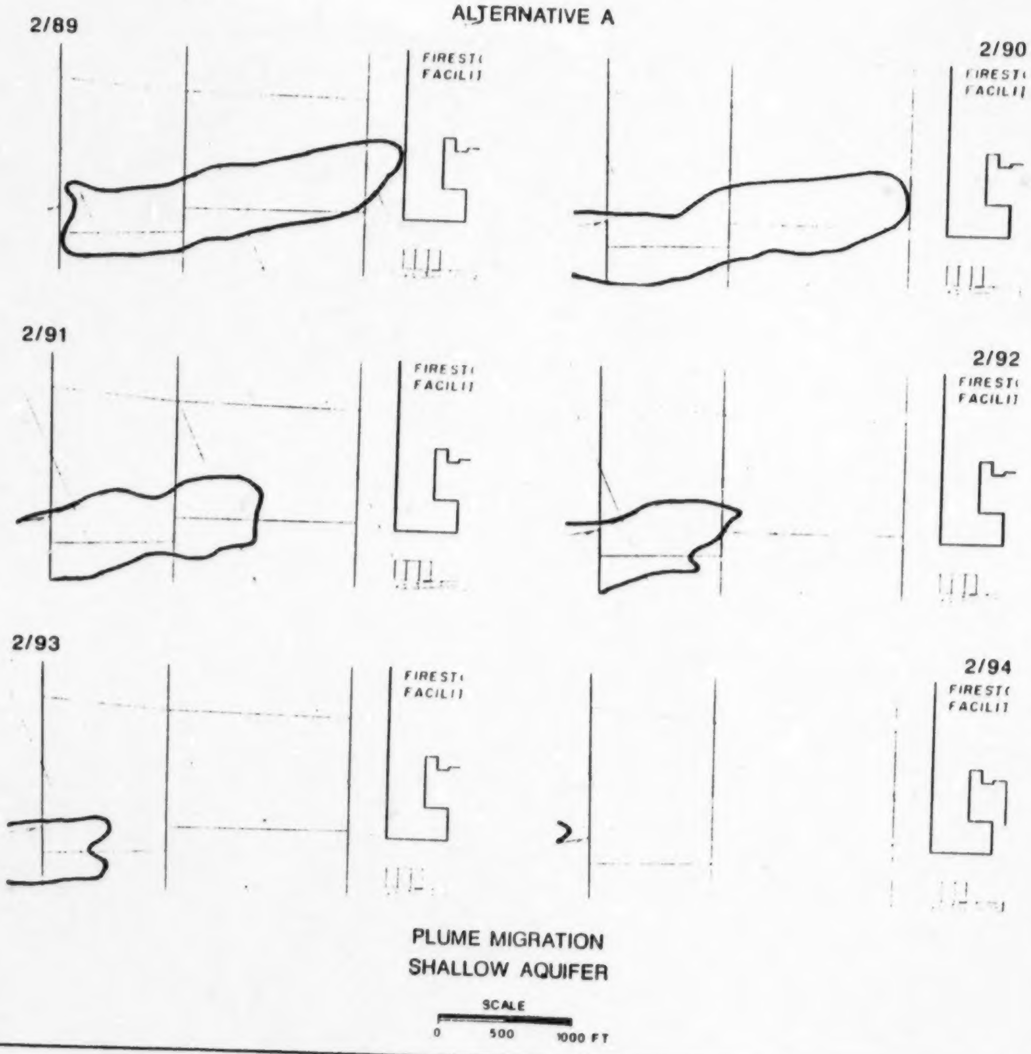
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SHALLOW AQUIFER
SCALE
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1000 FT

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4 1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-1A

ALTERNATIVE A
PLUME MIGRATION
SHALLOW AQUIFER

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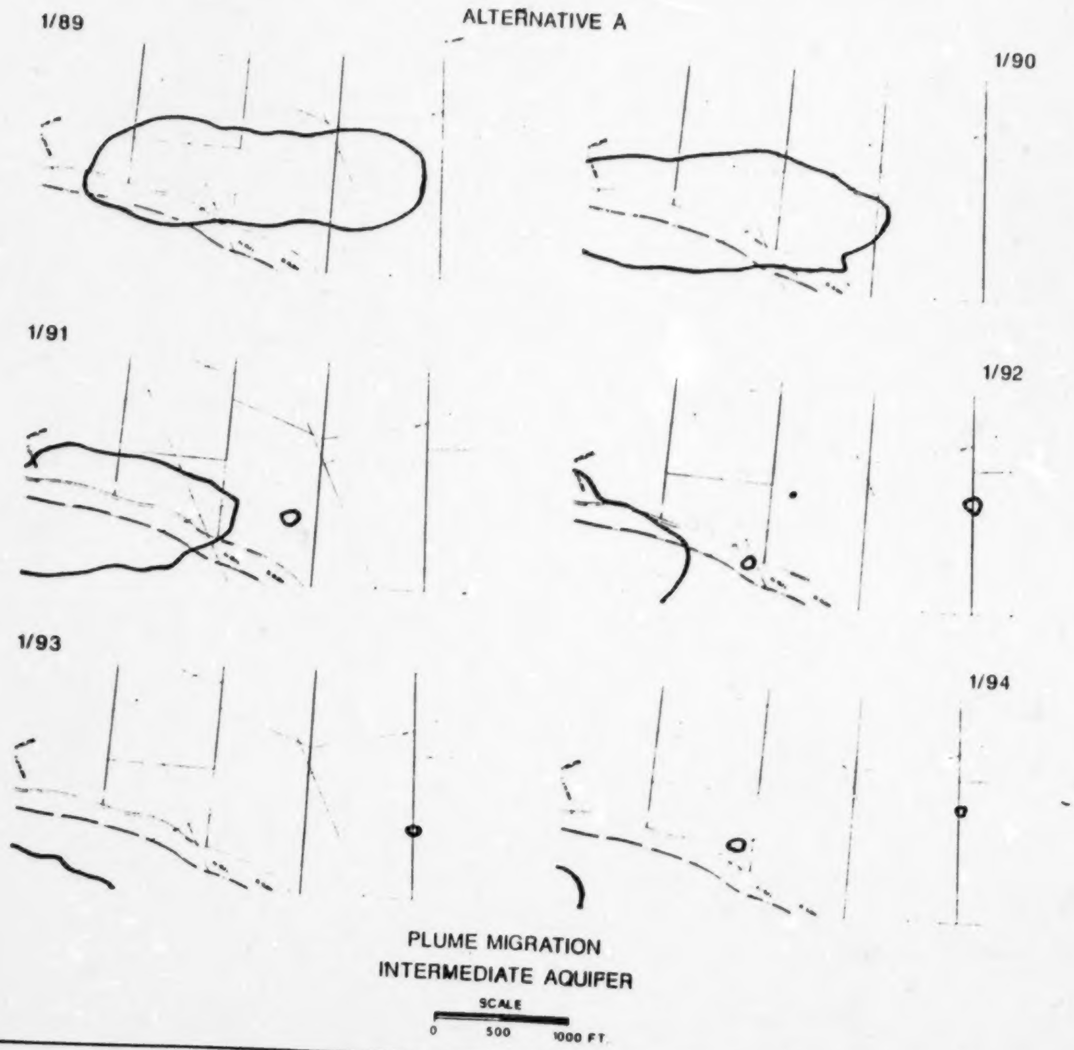
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PLUME MIGRATION
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NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-1B

ALTERNATIVE A
PLUME MIGRATION
INTERMEDIATE AQUIFER

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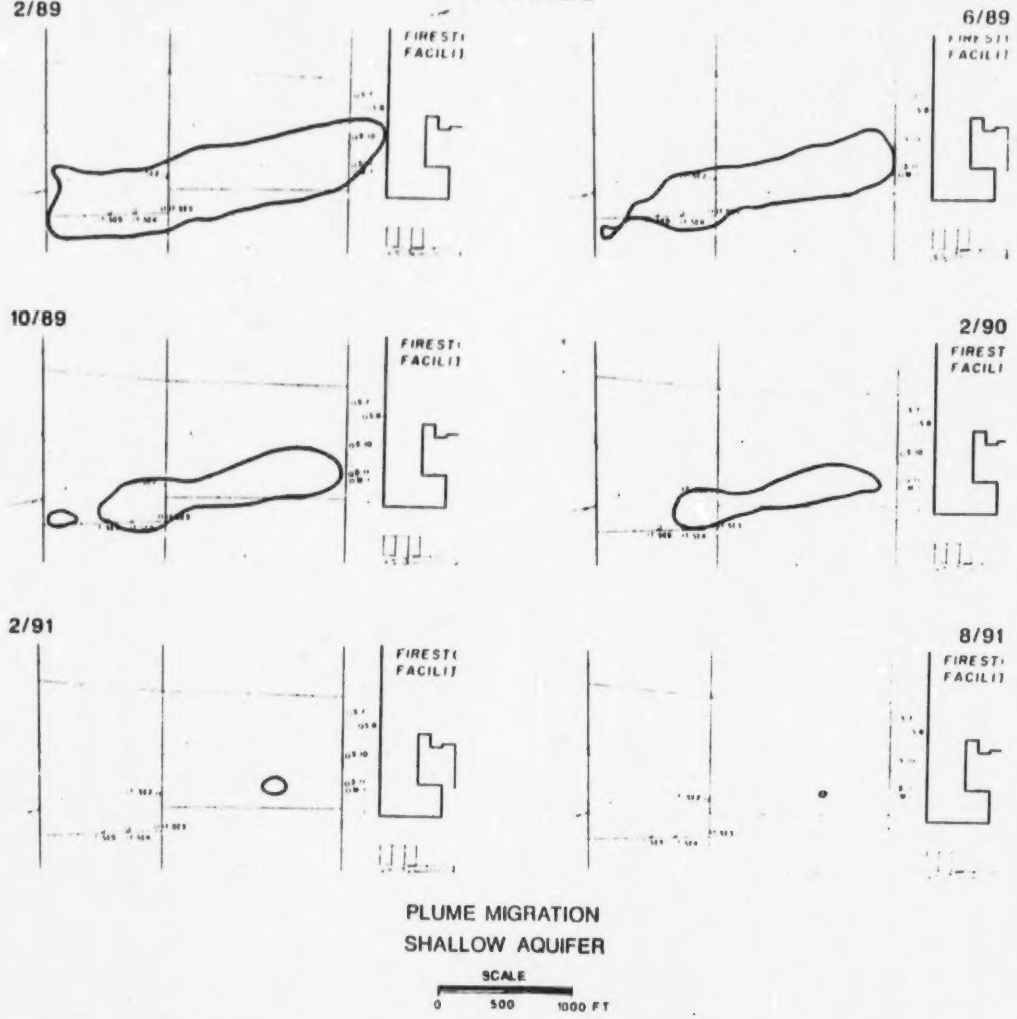
ALTERNATIVE B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FIRESTI FACILIT
SCALE
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PLUME MIGRATION
SHALLOW AQUIFER

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-2A

ALTERNATIVE B
PLUME MIGRATION
SHALLOW AQUIFER

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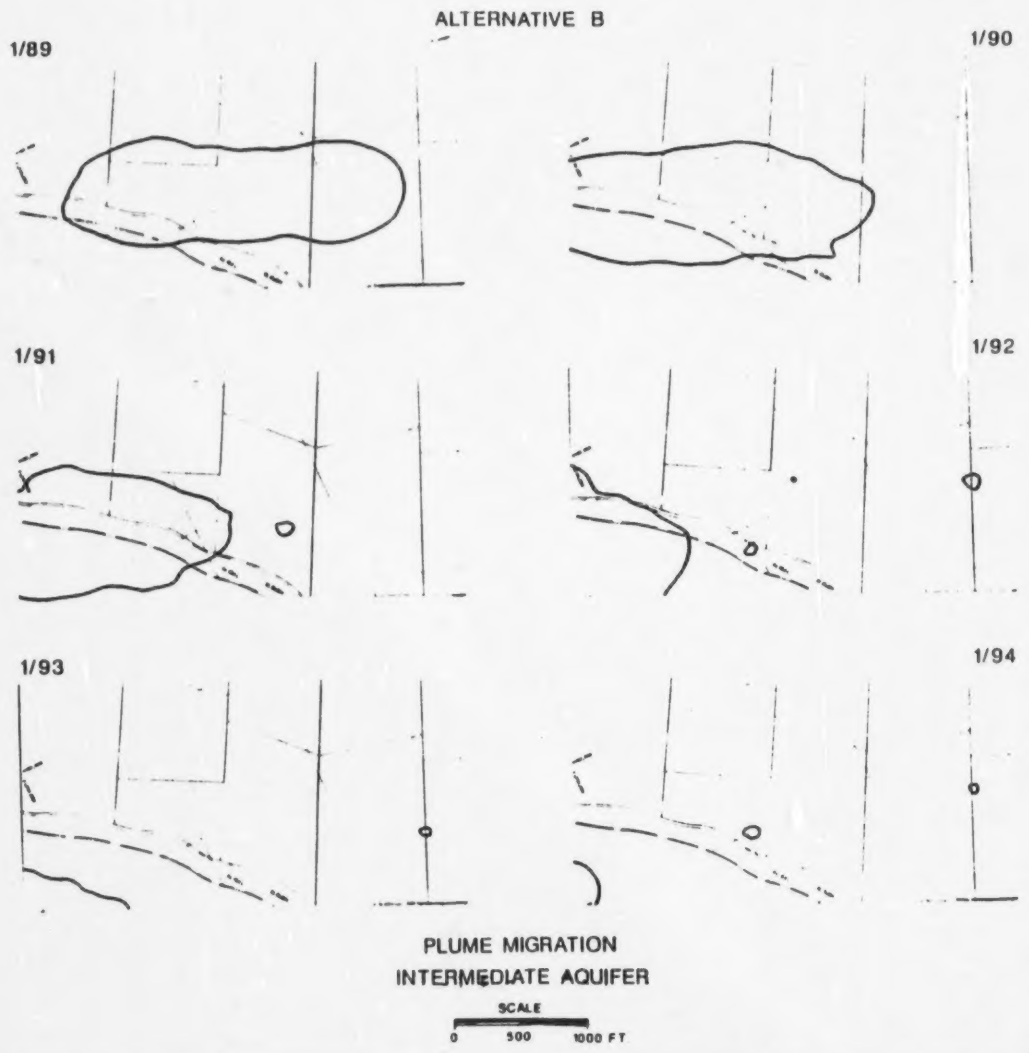
ALTERNATIVE B
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1/94
PLUME MIGRATION
INTERMEDIATE AQUIFER
SCALE
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500
1000 FT

NOTE:
FOR PLAN LOCATION OF MODEL
AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES
CLEANUP LEVELS FOR EACH
CONSTITUENT

FIGURE 4-2B

ALTERNATIVE B
PLUME MIGRATION
INTERMEDIATE AQUIFER

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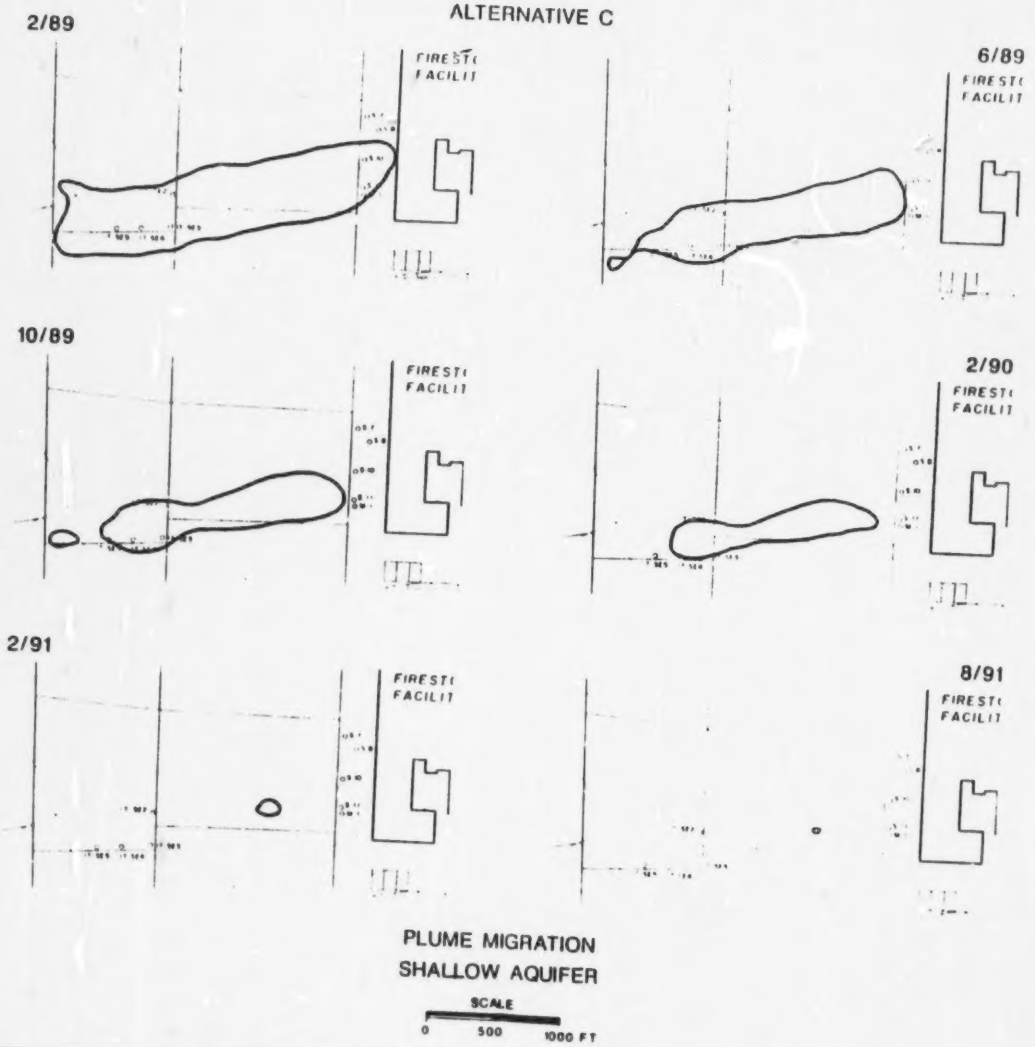
ALTERNATIVE C
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PLUME MIGRATION
SHALLOW AQUIFER
SCALE
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NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-3A

ALTERNATIVE C
PLUME MIGRATION
SHALLOW AQUIFER

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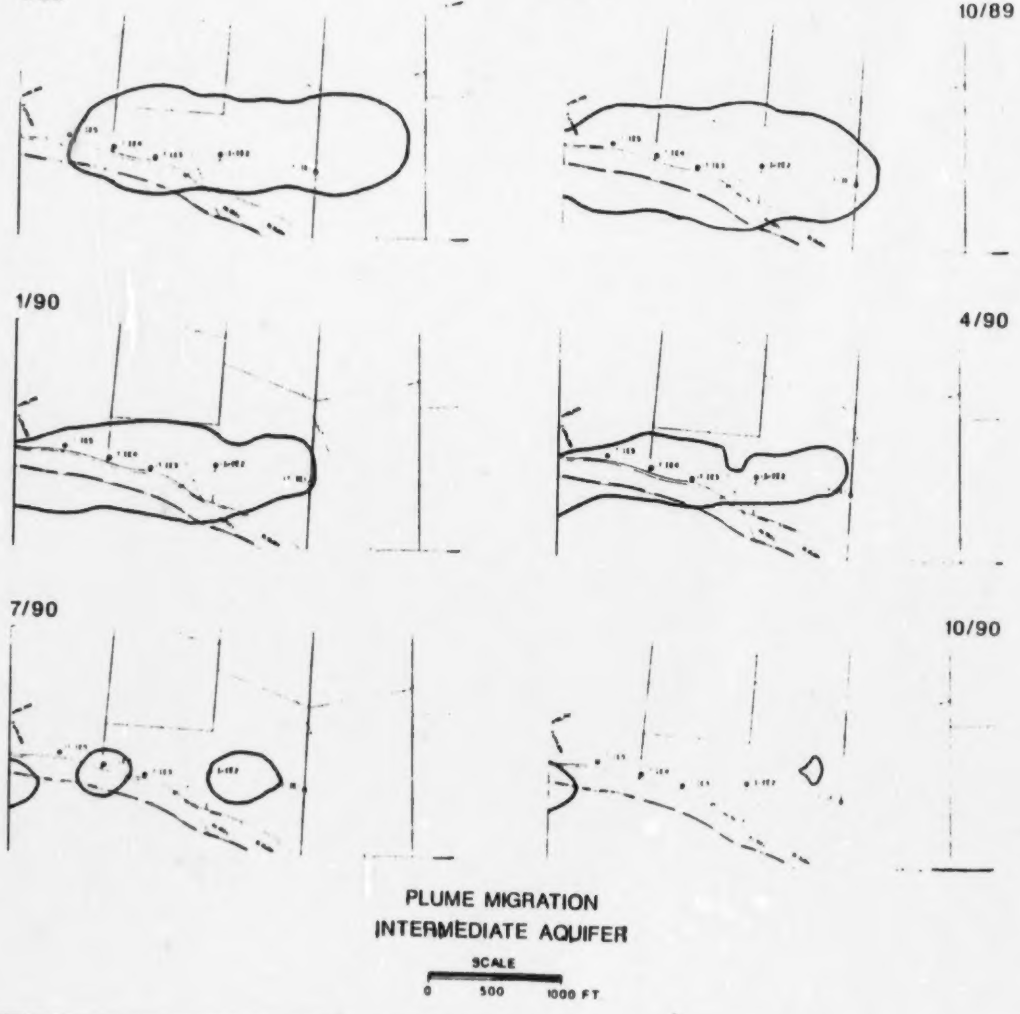
ALTERNATIVE C



PLUME MIGRATION
INTERMEDIATE AQUIFER

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-3B

ALTERNATIVE C
PLUME MIGRATION
INTERMEDIATE AQUIFER

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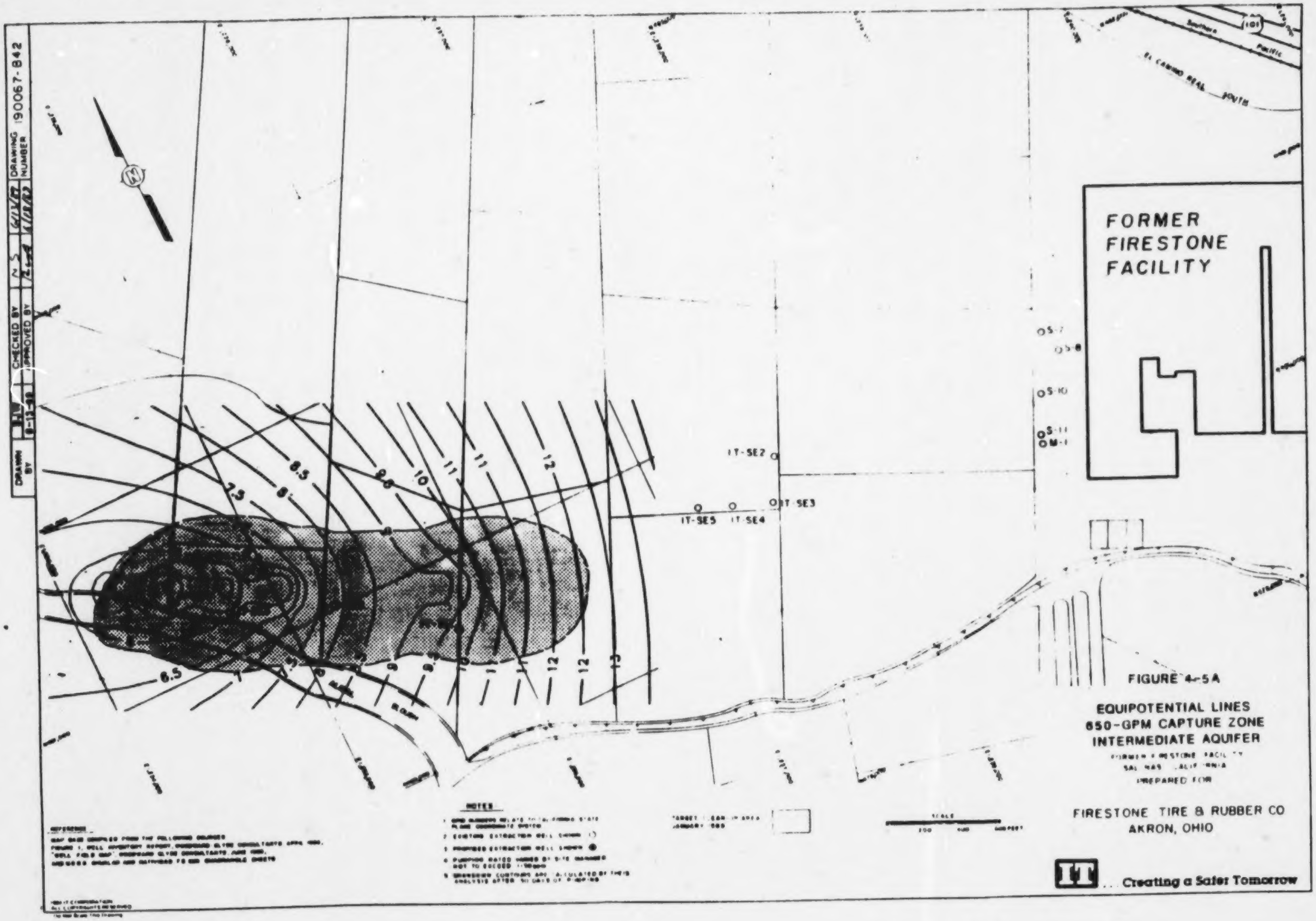
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EL CAMINO REAL SOUTH
Southern Pacific
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OS-10
OS-11
OM-1
IT-SE2
IT-SE3
IT-SE4
IT-SE5
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7.5
8
8.5
9
9.5
10
11
12
13
NOTES
SCALE

FIGURE 4-5A

EQUIPOTENTIAL LINES
650-GPM CAPTURE ZONE
INTERMEDIATE AQUIFER

PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

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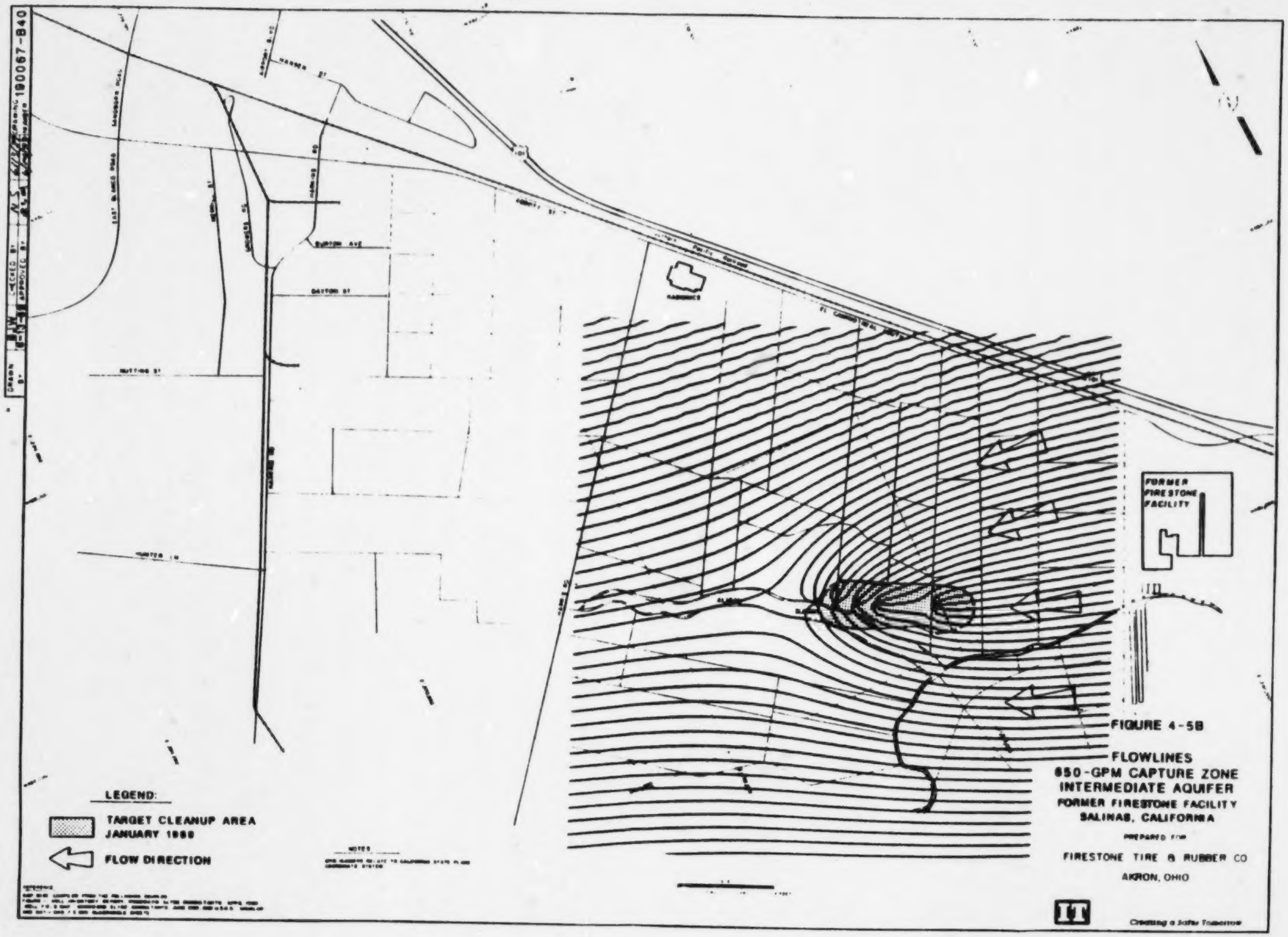
FORMER FIRESTONE FACILITY
LEGEND:
TARGET CLEANUP AREA JANUARY 1988
FLOW DIRECTION
190067-B40

FIGURE 4-5B

FLOWLINES
650-GPM CAPTURE ZONE
INTERMEDIATE AQUIFER
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

PREPARED FOR

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AKRON, OHIO

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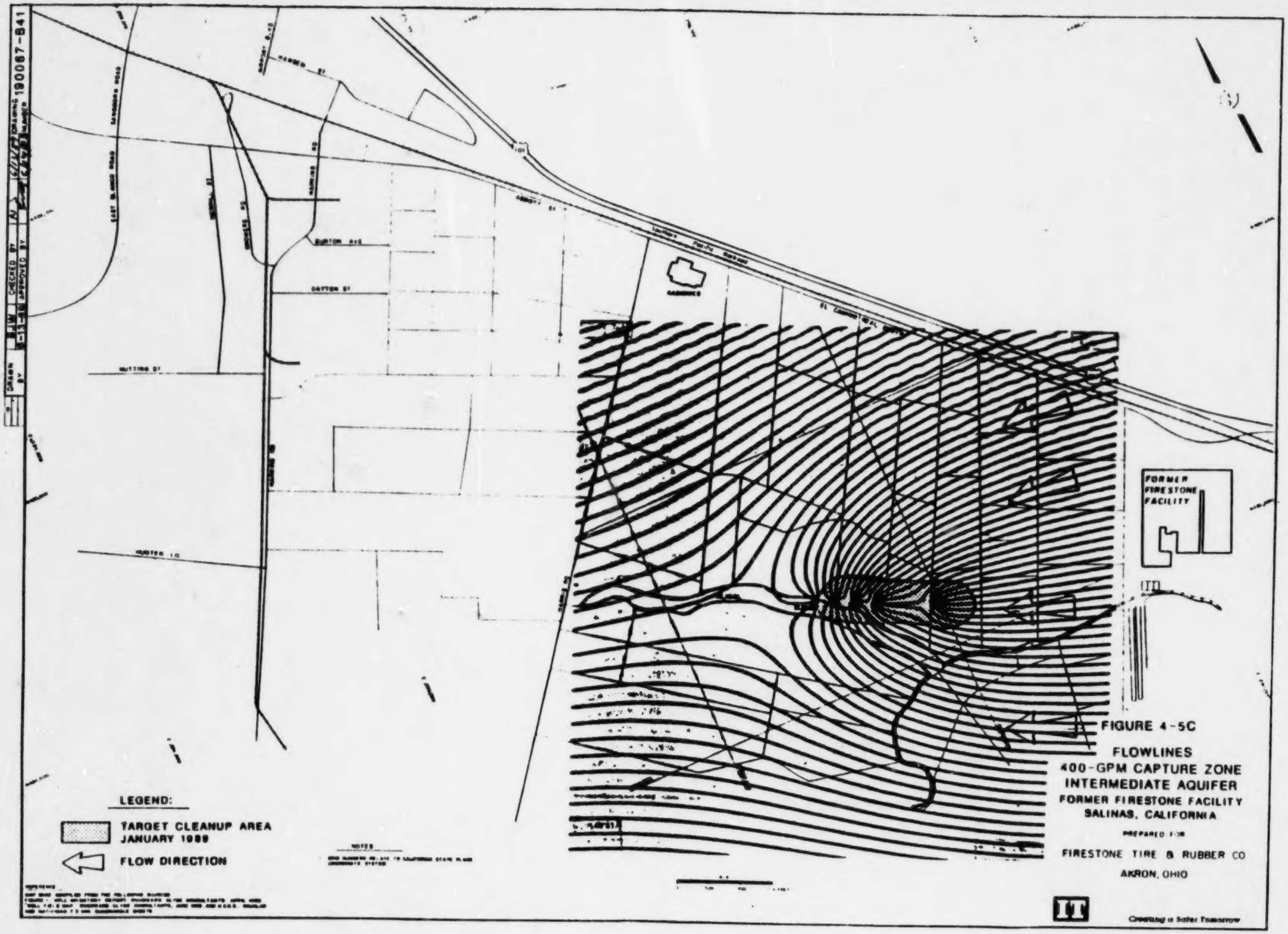
FORMER FIRESTONE FACILITY
LEGEND:
TARGET CLEANUP AREA JANUARY 1989
FLOW DIRECTION
DRAWN BY
CHECKED BY
APPROVED BY
DRAWING NUMBER 190067-B41
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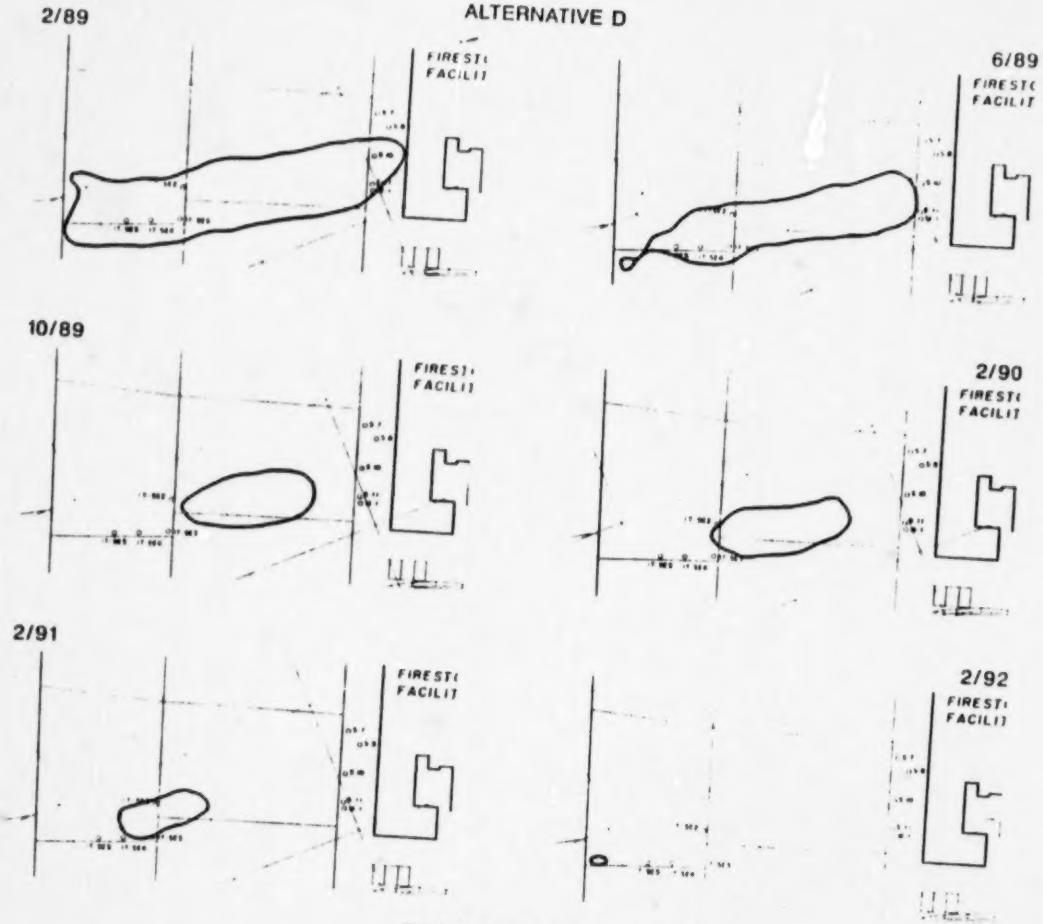
FIGURE 4-5C

FLOWLINES
400-GPM CAPTURE ZONE
INTERMEDIATE AQUIFER
FORMER FIRESTONE FACILITY
SALINAS, CALIFORNIA

PREPARED FOR

FIRESTONE TIRE & RUBBER CO
AKRON, OHIO

ALTERNATIVE D


2/89
6/89
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FIRESTC FACILIT

PLUME MIGRATION
SHALLOW AQUIFER

SCALE
0
500
1000 FT

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-6A

ALTERNATIVE D
PLUME MIGRATION
SHALLOW AQUIFER

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TECHNOLOGY
CORPORATION

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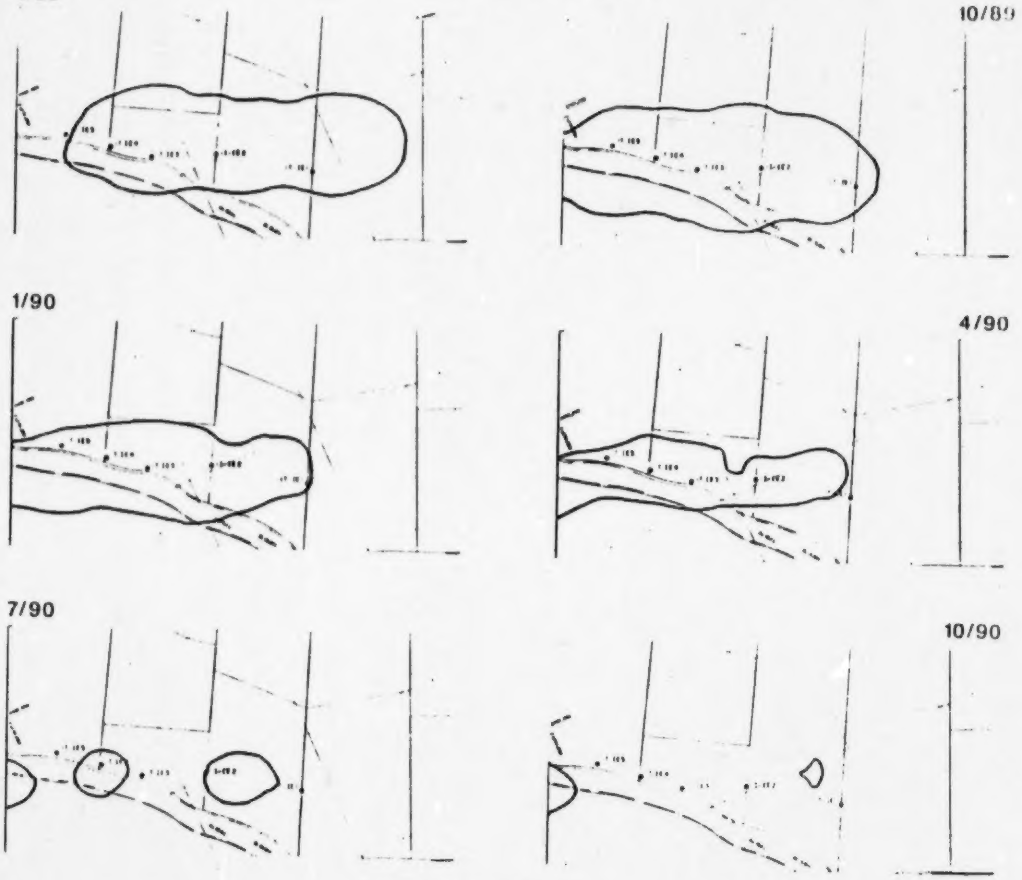
ALTERNATIVE D



PLUME MIGRATION
INTERMEDIATE AQUIFER

NOTES:

- OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT
- FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1
- PUMPING RATE 650 gpm
- START OF PUMPING OCTOBER 1989

FIGURE 4-6B

ALTERNATIVE D
PLUME MIGRATION
INTERMEDIATE AQUIFER

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TECHNOLOGY
CORPORATION

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9-1-89

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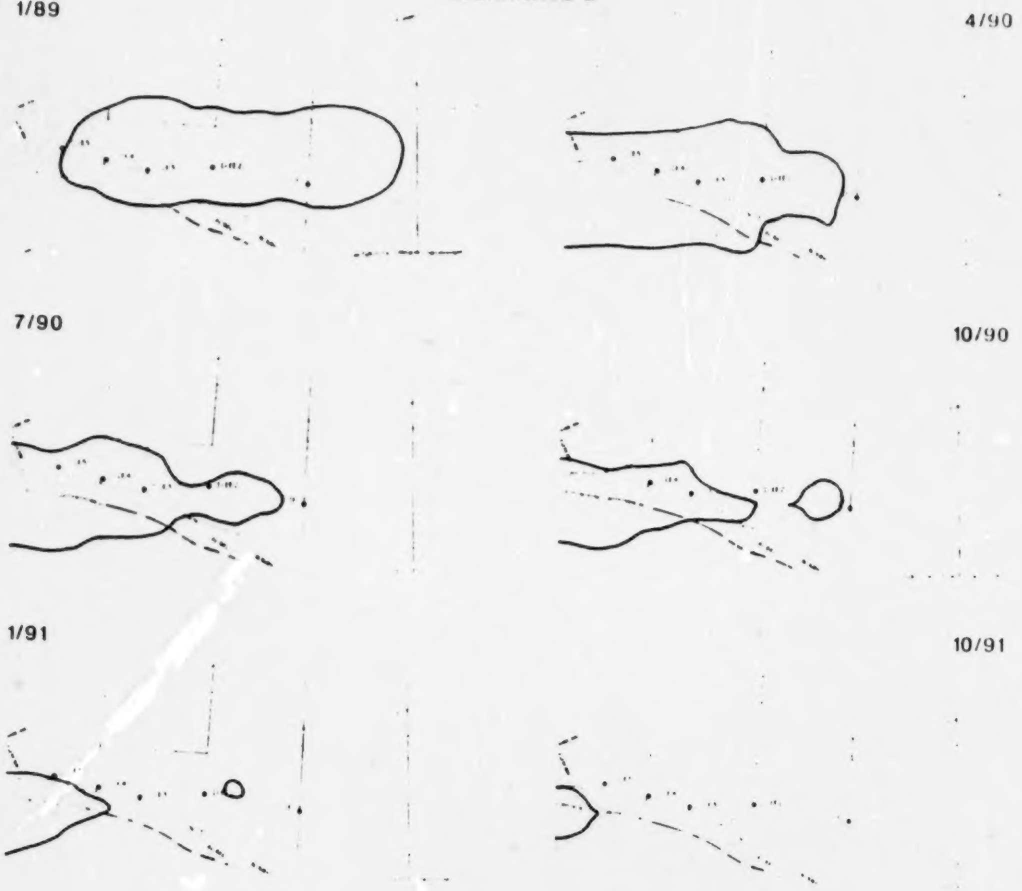
ALTERNATIVE D'



PLUME MIGRATION
INTERMEDIATE AQUIFER

NOTES:

- OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT
- FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1
- PUMPING RATE 650 gpm
- START OF PUMPING APRIL 1990

FIGURE 4-6C

ALTERNATIVE D'
PLUME MIGRATION
INTERMEDIATE AQUIFER

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9-1-89

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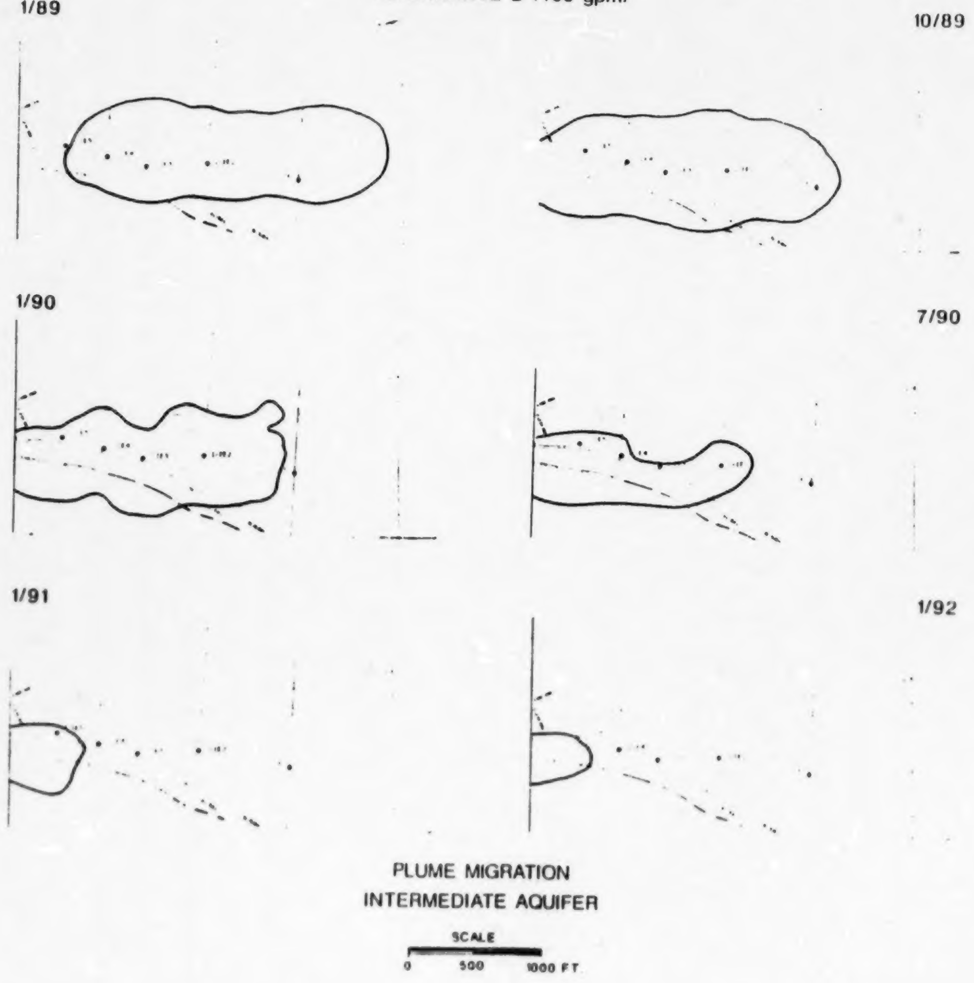
ALTERNATIVE D (400 gpm)


1/89
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7/90
1/91
1/92
PLUME MIGRATION
INTERMEDIATE AQUIFER
SCALE
0
500
1000 FT

NOTES:

- OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT
- FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4 1
- START OF PUMPING OCTOBER 1989

FIGURE 4 6D

ALTERNATIVE D (400 gpm)
PLUME MIGRATION
INTERMEDIATE AQUIFER

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5-26-89

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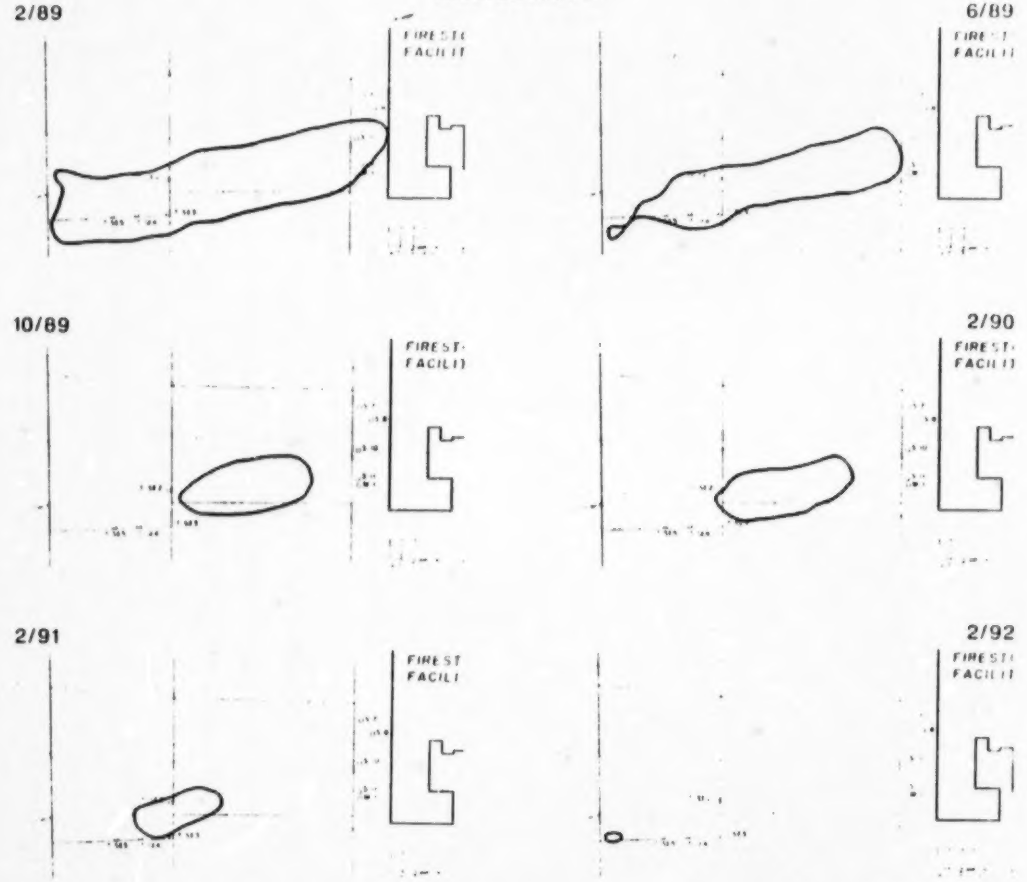
ALTERNATIVE E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PLUME MIGRATION
SHALLOW AQUIFER

SCALE
0 500 1000 FT

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 1-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-7A

ALTERNATIVE E
PLUME MIGRATION
SHALLOW AQUIFER

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AKRON, OHIO

INTERNATIONAL
TECHNOLOGY
CORPORATION

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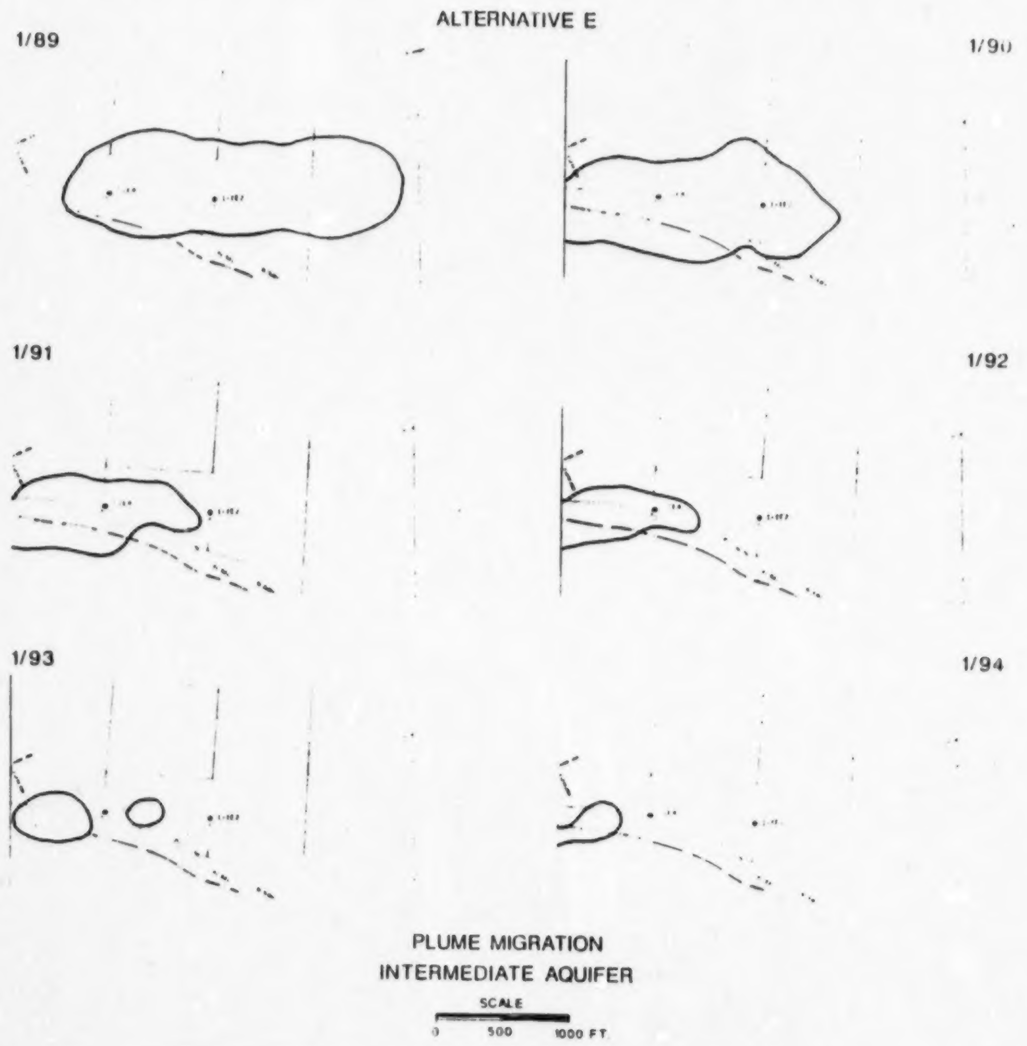
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PLUME MIGRATION
INTERMEDIATE AQUIFER
SCALE
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500
1000 FT

NOTE:

FOR PLAN LOCATION OF MODEL AREA SEE FIGURE 4-1

OUTLINED AREA ENCOMPASSES CLEANUP LEVELS FOR EACH CONSTITUENT

FIGURE 4-7B

ALTERNATIVE E
PLUME MIGRATION
INTERMEDIATE AQUIFER

PREPARED FOR

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TECHNOLOGY
CORPORATION

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9-1-89

DRAWN BY HDS 5/25/89

190067-B36

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

MEMORANDUM

SUBJECT: Adjustment of Risk Values and Recommendation for Groundwater Cleanup Levels at Firestone Salinas

TO: Alexis Strauss, Chief
Superfund Enforcement Branch

B Curnow

THRU: Betsy Curnow, Chief
Enforcement Programs Section

FROM: Jeff Dhont Jeff Dhont
Remedial Project Manager
Firestone Salinas Site

DATE: June 20, 1989

Purpose

The purpose of this memorandum is to explain certain adjustments which were made in risk calculations for the Firestone Salinas Site, and to provide a rationale for selection of groundwater cleanup levels at the Site.

Recommendation

This memorandum will recommend that the cleanup levels established in the draft RAP be accepted as protective and in accordance with ARARs, provided that the cleanup level for 1,1-DCA is lowered from 20 ppb to 5 ppb.

Introduction to Background and Issues

Firestone submitted a final draft FS/RAP to DHS on June 5, 1989. The RAP sets cleanup levels for the groundwater remediation effort at the Site, based on both risk and ARARs. To be able to address these proposed cleanup levels, EPA has had to perform three tasks:

1) Make adjustments and correct certain errors in the manner in which risk calculations were made for the Site;

2) Address the issue of whether 1,1-DCE is to be treated as a carcinogen in the quantitative risk assessment;

3) Firestone used a rather unusual method for arriving at the cleanup levels. EPA must compare the results of Firestone's method with the results that would be obtained by EPA's method and

decide whether the proposed cleanup levels are acceptable from the EPA standpoint.

Note that the computation of cleanup levels is a related yet somewhat separate issue from the calculation of risk actually posed by the site. A quantitative risk assessment was performed to determine, under a probable worst-case scenario, what the risk would be from the site. This assumed that the concentration that people would be drinking for a seventy-year lifetime is a geometric mean of the concentrations found in affected wells.

With regard to cleanup levels, however, we are calculating the risks which would exist if concentrations were brought to the cleanup levels themselves. Rather than assessing exposure based on a geometric mean over affected wells, it is assumed that people are exposed to water at the cleanup levels themselves. In other words, it is assumed that each well constitutes a point of compliance and must meet the cleanup level requirement.

Each of the above three issues will now be discussed in turn.

Adjustments in Calculations

The following adjustments and recalculations were required in order to assess the appropriateness of the proposed cleanup levels:

1. Certain values for cancer potency factors had been updated without Firestone's knowledge. Recalculation was required using the new CPF values.

2. Noncarcinogenic effects of carcinogens had not been included in the calculation of the original site risk. When these were included and a new hazard index computed for the site, the HI was still insignificant (< 0.01), and so it became apparent that the cancer risk would drive the cleanup level selection.

3. 1,1-DCA had not been treated by Firestone as a carcinogen. Recalculations were required which incorporated 1,1-DCA in the cancer assessment.

4. Firestone had not considered inhalation exposure in its risk calculations. Primarily at issue here was the inhalation of volatile organics by persons while in the shower. A standard estimation was used, which has been used by EPA while awaiting the results of indoor shower inhalation studies. This is that the exposure to chemicals by inhalation, i.e. the dose, is equal to the exposure from ingestion of drinking water. Making this assumption does not merely double the risk because cancer potency factors for inhalation may vary from those for ingestion. Thus, a separate inhalation risk calculation must be made and added to the ingestion risk to obtain the total risk.

1,1-Dichloroethylene as a Carcinogen

1,1-Dichloroethylene (1,1-DCE) is currently the primary contaminant at Firestone. In all likelihood, if its concentration were reduced by remediation to the Action Level of 6 ppb, all other contaminants would be non-detectable. At issue is whether it is appropriate to treat 1,1-DCE in a quantitative risk assessment, or to base its cleanup on ARARs. Upon review with Regional Toxicologist Gerald Hiatt and discussion with DHS toxicologists, the following points and recommendation have emerged with regard to this issue.

1,1-DCE is a Class C Agent, "Possible Carcinogen" (as distinguished from chemicals classified as Class A, "Known Human Carcinogens", or Class B, "Probable Human Carcinogens"). EPA's practice with respect to risk assessment and setting cleanup levels is to treat Class C Agents on a case-by-case basis, using either a modified-RfD approach or a quantitative risk assessment. The modified-RfD approach is similar to the RfD calculation normally used for non-carcinogens; additional safety factors are introduced to take into account the carcinogenic potential of Class C agents and the possibility of multiple routes of exposure to the chemical. This approach is often used by EPA's Office of Drinking Water (ODW) in setting MCLGs; accordingly, when used it generally results in cleanup numbers based on ARARs. The use of the approach is particularly appropriate for those Class C agents where the evidence for carcinogenicity is especially weak. In such cases, the use of quantitative cancer risk assessment can produce less useful or even misleading results.

For 1,1-DCE in groundwater, the available data support the use of the modified-RfD approach to setting cleanup levels. The number of negative cancer studies on 1,1-DCE is notable. Five oral carcinogenicity studies have been conducted on 1,1-DCE, including a lifetime joint study by the National Cancer Institute and the National Toxicology Program. All of these oral cancer studies were negative. Eleven studies on 1,1-DCE evaluated carcinogenic potential via inhalation; ten were negative. One study, by Maltoni, did produce evidence of carcinogenic potential in mice, although this interpretation is blurred somewhat by lack of a clear dose-response relationship. A similar study by the same group of investigators did not produce cancer in rats, even though doses of up to six-fold higher were administered. Thus, the evidence supporting classification of 1,1-DCE as a "carcinogen" are especially weak.

At Firestone, if 1,1-DCE is treated as a carcinogen in a quantitative risk assessment, rather than using the modified-RfD approach, then at the DHS Action Level of 6 ppb it will single-handedly put the risk for the site at greater than 3.5E-4. In order to bring the risk below 1.0E-4, the cleanup level for 1,1-DCE would have to be set at 1 ppb or less.

After reviewing this issue and consulting with Gerald Hiatt, I recommend that 1,1-DCE be removed from the quantitative cancer risk calculation, and that its DHS Action Level of 6 ppb (the EPA MCL is 7 ppb) be considered protective. This is in accordance with ODW's decision to use qualitative rather than quantitative risk assessment in setting the MCLG (MCL and MCLG are equal for 1,1-DCE) for this chemical.

In the risk calculations which follow, it is assumed that all wells at Firestone will meet the DHS Action Level of 6 ppb for 1,1-DCE, and that this will be considered protective. Accordingly, 1,1-DCE is not included in the risk calculations.

Firestone's Method of Cleanup Level Derivation

Protectiveness of Proposed Cleanup Levels

In determining the proposed cleanup levels, Firestone determined the 1.0E-6 cancer risk level or each carcinogen as if it were alone. In other words, sum risk was not calculated. Then, where the lowest ARAR for any chemical was lower than the 1.0E-6 risk for that compound, the ARAR replaced the 1.0E-6 level as the proposed cleanup level. Of course, in doing this, Firestone had not made any of the necessary adjustments discussed above, such as incorporation of inhalation exposure.

Firestone's method bears several discrepancies with standard EPA risk assessment guidelines. However, EPA will accept risk in the 10^{-4} to 10^{-7} range when comparing risks against ARARs. Even though Firestone did not calculate a cumulative risk in its cleanup level calculation, it did use a 10^{-6} point of departure on each compound. It was therefore possible, regardless of the nature of Firestone's method, that the resulting cleanup levels were acceptable anyway. This potential was assessed and the results can be seen in the accompanying Tables.

The Tables show cumulative risks, including inhalation exposure and treating 1,1-DCA as a carcinogen. The first Table computes the excess cancer risk assuming that all chemicals are present at Firestone's proposed cleanup levels. The second Table computes the excess cancer risk assuming that all the chemicals are present at the lowest ARAR for each chemical.

PLEASE NOTE that in the first Table, the proposed cleanup level (PCL) for 1,1-DCA has been entered as 5 ppb, instead of Firestone's actual proposed level of 20 ppb. This is because: 1) DHS has an Action Level of 5 ppb, and may propose an MCL of the same in the near future, and 2) if the level of 1,1-DCA is left at 20 ppb, the total risk will exceed 1.0E-4. It is therefore assumed that the level for this compound will be lowered to 5 ppb. From an engineering standpoint, this will make little difference in remediation, because when 1,1-DCE is reduced to its action level of 6 ppb, 1,1-DCA will remain at levels far below 5 ppb, barring very unusual circumstances.

It can be seen from the first Table that the proposed cleanup levels provide for a total risk not exceeding 3.3E-5 (assuming, of course, that 5 ppb is used for 1,1-DCA instead of 20ppb).

In the second Table, it can be seen that the cleanup levels (except for 20 ppb for 1,1-DCA) are all equal to or lower than the lowest ARAR for the compound. It can also be seen that, even if all the cleanup levels were raised to the ARARs, the risk would still be acceptable at 4.1E-4. Thus, with the exception of 20 ppb for 1,1-DCA, Firestone's proposed cleanup levels (PCLs) are protective from a risk standpoint and meet applicable ARARs. This is true even though the method of deriving the cleanup levels may not have completely conformed to EPA's method for such computations.

Conclusion

The following is recommended:

1. 1,1-DCE be removed from the quantitative (cleanup level) risk assessment and a level of 6 ppb be considered protective;

2. the cleanup level for 1,1-DCA be lowered from 20 ppb to 5 ppb;

3. the cleanup levels proposed by Firestone (except for 1,1-DCA) be considered protective and in accordance with ARARs and therefore that EPA concur with their adoption;

4. the RAP declare that these levels shall be met in each and every monitoring well before cleanup can be considered attained.

If the above is adopted, the risks at the site from groundwater will be acceptable even though the method Firestone used to calculate the cleanup levels did not exactly conform to our method.

FIRESTONE SALINAS SUPERFUND PROJECT

Assessment of Excess Cancer Risk at Proposed Groundwater Cleanup Levels

CHEMICAL [CAS NO.]	ORAL CPF	INHAL CPF	PROP. CLEANUP LEVEL (ug/l)	DOSE AT PCL (mg/kg/day) (*1)	D.W. RISK AT PCL	INHAL RISK AT PCL	TOTAL RISK AT PCL
1,2-DICHLOROETHANE (1,2-DCA) [107-06-2]	9.1E-2	9.1E-2	0.5	1.4E-5	1.3E-6	1.3E-6	2.6E-6
TRICHLOROETHYLENE (TCE) [79-01-6]	1.1E-2	1.3E-2	3.2	9.1E-5	1.0E-6	1.2E-6	2.2E-6
TETRA-CHLOROETHYLENE (PCE) [127-18-4]	5.1E-2	3.3E-3	0.7	2.0E-5	1.0E-6	6.6E-8	1.1E-6
BENZENE [71-43-2]	2.9E-2	2.9E-2	0.7	2.0E-5	5.8E-7	5.8E-7	1.2E-6
1,1-DICHLOROETHANE (1,1-DCA) [75-34-3]	9.1E-2	9.1E-2	5 (*2)	1.4E-4	1.3E-5	1.3E-5	2.6E-5
TOTAL RISKS AT PROPOSED CLEANUP LEVELS =======>					1.7E-5	1.6E-5	3.3E-5

CPF = Cancer Potency Factor   PCL = Proposed Cleanup Level   D.W. = Drinking Water   INHAL = Inhalation

NOTE: Calculation assumes 70-kg body weight, and ingestion of 2 liters of water per day, over a 70-year lifetime.

(*1): The dose acquired through ingestion is assumed, for estimation, to be equal to the dose acquired by inhalation. This has been a standard EPA assumption while indoor inhalation studies are being performed and confirmed.

(*2): VERY IMPORTANT -- Firestone did not propose 5 ug/l in their FS RAP. The proposed value was 20 ug/l. This Table assumes that the PCL will be dropped to 5 ug/l. DHS has an action level of 5, and may issue an MCL at this level. Also, if the level for 1,1-DCA is left at 20 ug/l, the total risk will exceed 1.0E-4.

FIRESTONE SALINAS SUPERFUND PROJECT

Assessment of Excess Cancer Risk at Lowest Groundwater Standards (ARARs)

CHEMICAL [CAS NO.]	ORAL CPF	INHAL CPF	LOW ARAR ug/l	LOW ARAR NAME	CLASS OF CARC.	DOSE AT LOW ARAR (ug/kg/day) (*2)	D.W. RISK AT ARAR	INHAL RISK AT ARAR	TOTAL RISK AT ARAR
1,2-DICHLOROETHANE (1,2-DCA) [107-06-2]	9.1E-2	9.1E-2	0.5	CAMCL	B2	1.4E-5	1.3E-6	1.3E-6	2.6E-6
TRICHLOROETHYLENE (TCE) [79-01-6]	1.1E-2	1.3E-2	5	MCL	B2	1.4E-4	1.5E-6	1.8E-6	3.3E-6
TETRA-CHLOROETHYLENE (PCE) [127-18-4]	5.1E-2	3.3E-3	5	MCL	B2	1.4E-4	7.1E-6	4.6E-7	7.6E-6
BENZENE [71-43-2]	2.9E-2	2.9E-2	1	CAMCL	A	2.9E-5	8.4E-7	8.4E-7	1.7E-6
1,1-DICHLOROETHANE (1,1-DCA) [75-34-3]	9.1E-2	9.1E-2	5(*2)	A.L.	C	1.4E-4	1.3E-5	1.3E-5	2.6E-5
TOTAL RISKS AT LOWEST ARARS =======>							2.4E-5	1.7E-5	4.1E-5

CPF = Cancer Potency Factor PCL = Proposed Cleanup Level D.W. = Drinking Water INHAL = Inhalation

NOTE: Calculation assumes 70-kg body weight, and ingestion of 2 liters of water per day, over a 70-year lifetime.

(*1): The dose acquired through ingestion is assumed, for estimation, to be equal to the dose acquired by inhalation. This has been a standard EPA assumption while indoor inhalation studies are being performed and confirmed.

(*2): DHS action level of 5 ug/l. Expected MCL of 5 ug/l.